BOARD OF WATER SUPPLY

OF

THE CITY OF NEW YORK

LONG ISLAND SOURCES

Reports, Resolutions, Authorizations, Surveys and Designs Showing Sources and Manner of Obtaining

From Suffolk County, Long Island

AN ADDITIONAL SUPPLY OF WATER

FOR

THE CITY OF NEW YORK

Volume 2

New York City
1912

APPENDIX 6

PUMPING SYSTEM FOR COLLECTING WORKS

BY WALTER E. SPEAR, DIVISION ENGINEER, WITH ESTIMATES ON ELECTRICAL EQUIPMENT BY HORACE CARPENTER, ELECTRICAL ENGINEER

The proposed design for the Suffolk County collecting works requires some form of pump which can be operated economically through a suitable transmission system from one or more central power-stations; the centrifugal or the reciprocating pumps with drop suctions which are in use on the Ridgewood system of the Brooklyn works, for pumping groups of wells and infiltration galleries, would be impracticable for the complete development of the Suffolk County ground-waters proposed, because of the distance separating the units of the continuous line of wells and the limitations in the depth of pumping. Either an air-lift system operated from one or more compressor stations or a system of electrically driven pumps of the plunger centrifugal or turbine type, operated through a high tension transmission line from a central electrical power-station must be chosen.

The air-lift system offers many advantages over any other method of pumping in smaller depreciation and in greater ease of operation, but these advantages are more than offset by the low efficiency of the air-lift and the resulting high operating cost.

SYSTEM OF ELECTRICALLY DRIVEN PUMPS

The universal acceptance of the high tension electric current for long distance power transmission is sufficient proof of its superiority over that of pneumatic or hydraulic methods. There can be little question, therefore, of the applicability of a system of electric transmission and distribution of power for the proposed Suffolk County collecting works, the main line of which extends over a distance of 50 miles, if a highly efficient type of pump can be designed that can be operated with low maintenance and depreciation by means of an electrically driven motor.

Types of Pumps

There are several types of pumps on the market designed to be driven electrically, but none of them are quite suitable for the Suffolk County collecting works. Most of them do not appear to be highly efficient and all probably suffer some wear if any sand or grit be present in the water. A pump is required for the Suffolk County works that would continue to run economically for months at a time with but little attention.

THE P. K. WOOD PROPELLER PUMP

The P. K. Wood Pump Company, of Los Angeles, California, manufactures a pump that has been used in the west to some extent for deep well work. This pump consists of a series of propellers 2½ to 5 feet apart, rotating on a vertical shaft within a solid casing. The shaft is supported by spiders, or guides, at frequent intervals within this casing, and much trouble arose in the earlier patterns from the wear on these unprotected bearings, and the cutting of the casing, and the breaking of the propeller blades that resulted. It is claimed that these earlier difficulties have been, in part, obviated by the use of annular bearing rings of wood about the shaft.

The pump gives a large discharge, and the manufacturers claim from 50 to 75 per cent. efficiency. The available drawings of the propellers, however, show them to be somewhat crude, and the efficiency may possibly be less than that claimed. The bearings of this pump do not appear to be as well protected from wear as the next pump considered.

BYRON JACKSON "DEEP WELL VERTICAL TURBINE PUMP"

The "Deep Well Vertical Turbine" pump made by the Byron Jackson Machine Company, of San Francisco, California, is a multi-step centrifugal pump and efficiencies of 65 per cent. are said to have been obtained. The vertical shaft to which the motor and pumps are directly connected, is enclosed in an inner casing, which, it is claimed, protects the bearings from grit carried up by the water. If large wells were adopted in Suffolk county, there would be ample space for a centrifugal pump of this type, having sufficient capacity for the proposed development.

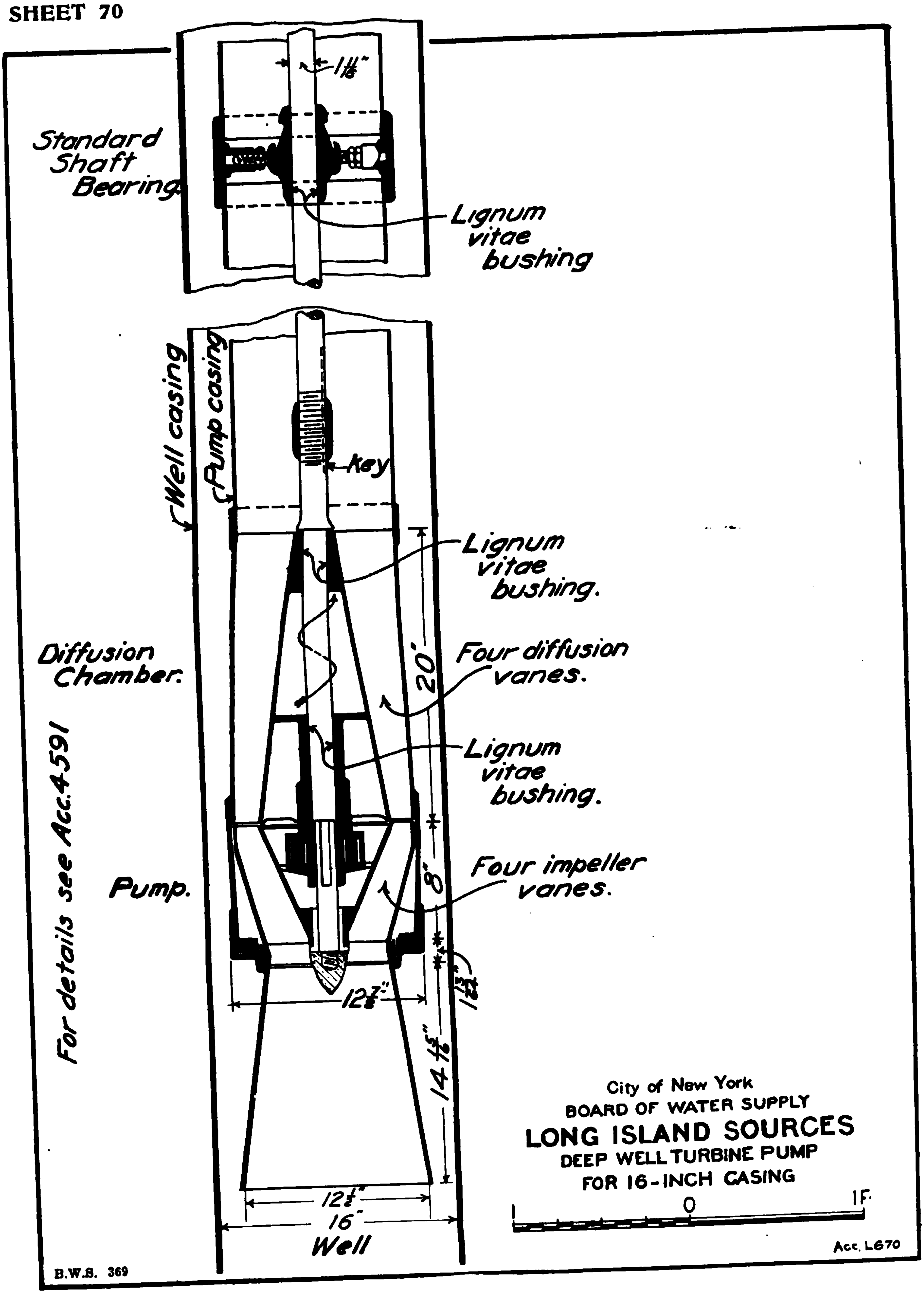
THE TURBINE PUMP

A type of pump of the turbine or impeller type has been proposed recently. It apparently offers some economy over the centrifugal pump and will also deliver a larger volume of water for a given diameter. This pump, like the centrifugal pump, is placed in the well below the lowest ground-water level; the water is drawn in and forced vertically upward by a set of rapidly revolving vanes or impellers, without change of direction. The Alvord pump is one of this type and efficiencies of 43 per cent. have been obtained. The feature of this pump is the device for balancing the thrust by the pressure of the moving water.

A promising design for a turbine pump is that submitted by Mr. Robert W. Steed, Mechanical Engineer, which has recently been tested at the Babylon experiment station. A sketch of this pump is shown on Sheet 70, Acc. L 670. It was designed for a maximum yield of two million gallons per day, which proved to be greater than the capacity of the well in which it was tested. For a delivery of 1.5 million gallons per day and a speed of 1200 revolutions per minute, an efficiency of about 45 per cent. was obtained. The well yielded much sand during the test because the rate of pumping was greater than that secured by means of the air-lift with which the well was originally cleaned up. But for the sand even better results would doubtless have been obtained. The sand cut the shaft bearings, and the clearances in the pump and subsequent experiments showed that this reduced the efficiency. Slight modifications in the design would doubtless avoid some of this wear, and studies should be made to this end. If the gravel filter about a stovepipe well were properly cleaned up and all the fine sand removed in the first place by heavier pumping than that of service operation, but little sand would afterwards be obtained.

PLUNGER PUMP

Some grit would doubtless be obtained from any well that might be used in Suffolk county and some wear would take place in the operation of even the most carefully designed pump. More depreciation is likely to occur, however, with pumps of the centrifugal or turbine type, because of their high speed of revolution and the high velocity of the water through them than with a pump that runs more slowly. It is not


1 1/16"
Standard Shaft Bearing
Lignum vitae bushing
Well casing
Pump casing
Key
Lignum vitae bushing.
Diffusion Chamber.
Four diffusion vanes.
20"
Lignum vitae bushing.
For details see Acc. 4591
Pump.
Four impeller vanes.
8"
1 3/4"
12 7/8"
14 1/16"
12 1/2"
16"
Well
City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
DEEP WELL TURBINE PUMP
FOR 16-INCH CASING
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1 F.
Acc. L670
B.W.S. 369

pleasant to speculate on the damage that might occur to a pump and motor running at a speed of 1200 to 1500 revolutions per minute should any part of the pump wear and loosen, and the motor be allowed to run without attention for several hours. A pump that will run at a slower speed is certainly desirable and studies should be made for a large but compact plunger pump, having a piston speed of, say, 50 to 75 feet per minute. Pumps of this type on the market are driven through a train of gears by an electric motor. For the Suffolk County works a pump of this kind could be geared to an induction motor and the speed reduced as low as desired. Even with the losses incident to this reduction of speed, the high efficiency of a double acting plunger pump would probably be sufficient to give a combined efficiency quite as high as that of the centrifugal or turbine pumps direct connected to a vertical motor.

Pump Efficiency

Whatever type of pump is adopted for the proposed development, the efficiency should not be less than 50 per cent. and this figure has been adopted in the preliminary estimates on the design and cost of the pumping system.

ESTIMATES ON ELECTRICAL PUMPING SYSTEM

BY HORACE CARPENTER, ELECTRICAL ENGINEER

The general plan of the proposed electrical pumping system would comprise, a power-station located on the water-front at or near the village of Patchogue; the necessary transmission lines extending from that station along the proposed aqueduct and connecting to various substations from which the power would be distributed to individual wells, located along this line.

The location of the substations proposed are shown on Sheet 71, Acc. L 671, and the estimated number of wells, the average and maximum yield and lift, and the power required for each substation estimated at the engine shaft are presented in Table 26. These stations and the sections they operate are grouped into the several successive developments that are proposed for the Suffolk County works. The locations of the sections are given in Table 25, page 321. The average yields given in the first three stages exceed by 16

SHEET 71

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B.W.S. 280

TABLE 26

OUTPUT OF ELECTRIC SUBSTATIONS

Section No.	Number of Wells in This Section	Average Rate of Operation: Supply from this Section in Million Gallons Daily	Average Rate of Operation: Average Lift in Feet	Average Rate of Operation: K.W. Output of Substations with Total Efficiency Engine to Well of 33.4 per cent.	Maximum Rate of Operation: Supply from this Section in Million Gallons Daily	Maximum Rate of Operation: Average Lift in Feet	Maximum Rate of Operation: K.W. Output of Substations with Total Efficiency Engine to Well of 33.4 per cent.
FIRST STAGE OF DEVELOPMENT TO GREAT RIVER, 14.7 MILES							
8......	28	27	27	286	33	41	530
6......	30	24	32	302	35	43	589
5......	35	20	30	236	35	45	619
3......	18	9	35	124	18	46	325
Total.	**111**	**80**	**30**	**936**	**121**	..	**2,063**
ADDITIONAL DEVELOPMENT FOR SECOND STAGE TO SOUTH HAVEN, 14.8 MILES							
3......	16	11	38	164	16	46	290
2......	30	23	38	344	30	51	601
1......	32	21	40	330	30	52	614
9......	30	21	41	338	30	55	648
10......	13	9	43	152	13	56	283
Total.	**121**	**85**	**40**	**1,328**	**119**	..	**2,436**
ADDITIONAL DEVELOPMENT FOR THIRD STAGE TO QUOGUE, 18.9 MILES							
10......	18	13	46	235	18	54	375
12......	30	22	47	406	30	58	685
13......	30	12	49	231	20	60	472
14......	35	12	52	245	20	63	496
15......	35	12	55	260	20	66	520
Total.	**148**	**71**	**49**	**1,377**	**108**	..	**2,548**
ADDITIONAL DEVELOPMENT FOR FOURTH STAGE TO PECONIC VALLEY, 10.1 MILES							
16......	50	30	30	353	50	45	885
Transportation to Westhampton				840	..	..	1,050
ADDITIONAL DEVELOPMENT FOR FIFTH AND LAST STAGE, BRANCH LINES							
Melville Branch							
6......	12	..	..	...	10	50	197
7......	40	..	..	...	40	110	1,730
Total.	**52**	..	..	...	**50**	..	**1,927**
Connetquot Branch							
3......	20	..	..	...	15	60	353
4......	52	..	..	...	35	90	1,238
Total.	**72**	..	..	...	**50**	..	**1,591**
Carman's Branch							
10......	25	..	..	...	18	60	425
11......	54	..	..	...	32	80	1,020
Total.	**79**	..	..	...	**50**	..	**1,445**

million gallons per day the average supply of 250 million gallons per day that it is proposed to appropriate for New York City. The remainder might be required for the future supply of the local population, for industrial uses and for the maintenance of streams and ponds, and is therefore estimated.

Central Power-Station

The power-station would consist of the main power-house, the auxiliary coal storage and the machine-shop shown respectively on Sheets 75 and 76, Accs. 5344 and 5295. All buildings and foundations of this station would be entirely constructed under the first development of the aqueduct and collecting works and the coal storage and machine-shop completely equipped. The boilers, engines and generators would be installed as required by the various developments of the collecting works and aqueduct.

The full boiler-house equipment, as shown on Sheet 75, Acc. 5344, would comprise five batteries of water-tube boilers, four of which would be sufficient to furnish the maximum of required power, one battery being at all times held in reserve. These boilers would be equipped with mechanical stokers, economizers, feed pumps and an ash disposal system, and storage would be provided for about 2500 tons of coal on the second floor of the boiler room. It is proposed to locate the coal storage building between the power-station and the water-front, so that coal could be brought to it either by barge or by rail. This building would have a capacity of 10,000 tons, and would be equipped with a belt conveyor system for delivering the coal to the power-house.

The engine room would be ultimately equipped with six 1,500-K.W. turbine engines direct connected to 2200-volt, 60-cycle, 3-phase generators. Five of these sets, with their overload capacity, would be capable of handling the entire station load, leaving one set in reserve. Excitation for these generators and power for local purposes would be furnished by two direct-current turbo-generators, and one motor generator set. The easterly end of the power-house would be devoted to offices, and the " step-up " transformers, lightning arresters and oil switches for high-voltage transmission would be placed in the basement of the westerly end. The condensing apparatus for the turbines would be located in the basement between the two rows of turbines as shown.

The machine-shop could be built adjacent to the main power-house at any convenient point, and would be so equipped that all necessary repairs for the entire Suffolk County system could be done there.

The average and maximum pumpage, the probable maximum power output and the equipment provided for each stage is as follows:

Stage of Development	Maximum Yield of Collecting Works Million Gallons	Maximum Power Required at Engine Shaft K.W.	Proposed Equipment at this Stage Excluding Exciters K.W.
1	120	2,063	3,000
2	240	4,499	6,000
3	300	7,047	7,500
4	300	8,500	7,500
5	300	9,300	9,000

The cost of this equipment for the various stages of development is estimated as follows:

COST OF POWER-STATION

		Totals
DEVELOPMENT 1		
Foundations	$64,000	
Buildings		
Power-house	421,000	
Coal storage	212,000	
Machine-shop	25,000	
Equipment		
2 sets: Boilers, stack, economizers, etc.	108,000	
2 sets: Turbines, generators, transformers, etc.	124,000	
Coal conveyors	55,000	
Machine tools	6,000	
	$1,015,000	
Engineering and contingencies—20 per cent	203,000	
	$1,218,000	$1,218,000
DEVELOPMENT 2		
2 sets: Boilers, economizers, etc.	$100,000	
2 sets: Turbines, generators, etc.	115,000	
	$215,000	
Engineering and contingencies	43,000	
	$258,000	1,476,000
DEVELOPMENT 3		
1 set: Boilers, economizers, etc.	$58,000	
1 set: Turbines, generators, etc.	50,000	
	$108,000	
Engineering and contingencies	22,000	
	$130,000	1,606,000
DEVELOPMENT 4		
No additions		1,606,000
DEVELOPMENT 5		
1 set: Boilers, economizers, etc.	$58,000	
1 set: Turbines, generators, etc.	50,000	
	$108,000	
Engineering and contingencies	22,000	
	$130,000	$1,736,000

TRANSMISSION LINE

The power transmission line would be a double-circuit, 3-phase, 22,000-volt system, supported on reinforced concrete poles, the average spacing between poles being 300 feet. Wherever practicable, these poles would be equipped with the necessary cross arms to support the distribution and control circuits from the substations. Those parts of the distribution and control circuits which require it, would be supported on lighter poles spaced 150 feet apart. In making up the estimates of cost of this line, it has been assumed that as each development is made, the transmission line would be erected the entire distance, from the power-house to that development, at its ultimate capacity in cable, so that as additional developments are made, it would be unnecessary to change the conductors of any lines already erected. This would naturally increase the cost of the first and third developments over what that cost would be if the circuits were merely erected of the capacity necessary to serve those developments; and it might be advisable in the first and perhaps in the third development to effect some economy in this direction, if the entire system were not to be completed for some years.

The estimated cost of the transmission line is as follows:

			Total
Development 1, 22.1 miles	$118,000		
Engineering and contingencies	24,000	**$142,000**	**$142,000**
Development 2, 8.5 miles	55,000		
Engineering and contingencies	11,000	**66,000**	**208,000**
Development 3, 15.8 miles	94,000		
Engineering and contingencies	19,000	**113,000**	**321,000**
Development 4, 6 miles	31,000		
Engineering and contingencies	6,000	**37,000**	**358,000**
Development 5, 10.2 miles	42,000		
Engineering and contingencies	8,000	**50,000**	**408,000**

DISTRIBUTION SYSTEM

For the purpose of distribution it is proposed to install substations at points shown on Sheet 71, Acc. L 671. These stations would be equipped with the necessary "step-down" transformers to reduce the voltage from 22,000 to 2,200, and to distribute the power to each of the wells controlled by that particular substation, in such a manner that the motors at

each well could be started and stopped independently at the substation. For this purpose, there would be erected at each substation site, with the exception of Station 17, a building equipped as shown on Sheet 77, Acc. 5299. The building and equipment for Station 17 is shown on Sheet 112, Acc. 5345. This would be larger than that of the other stations on account of the installation of four centrifugal pump units, each of 14 million gallons daily capacity, to pump the Peconic Valley supply against 75-foot head over the hill located on that branch of the aqueduct. The cost of these substations and the distribution system for each development is estimated as follows:

				Total
	DEVELOPMENT 1			
4	Substations	$42,000		
	Substation equipment	68,000		
111	Pump-houses	89,000		
	Pumping motor and accessories	221,000		
	Distribution and control circuits	24,000		
		$444,000		
	Engineering and contingencies	89,000	$533,000	$533,000
	DEVELOPMENT 2			
4	Substations	$42,000		
	Substation equipment	61,000		
121	Pump-houses	97,000		
	Pumps, etc	244,000		
	Distribution and control circuits	19,000		
		$463,000		
	Engineering and contingencies	93,000	556,000	1,089,000
	DEVELOPMENT 3			
4	Substations	$42,000		
	Substation equipment	67,000		
148	Pump-houses	119,000		
	Pumps, etc	292,000		
	Distribution and control circuits	26,000		
		$546,000		
	Engineering and contingencies	109,000	655,000	1,744,000
	DEVELOPMENT 4			
1	Substation	$55,000		
	Substation equipment	50,000		
50	Pump-houses	40,000		
	Pumps, etc	96,000		
	Distribution and control circuits	23,000		
		$264,000		
	Engineering and contingencies	53,000	317,000	
	Deduct for pumps at Riverhead, to raise water over the hill, which belong to transportation works		75,000	
			242,000	1,986,000
	DEVELOPMENT 5			
3	Substations	$32,000		
	Substation equipment	68,000		
203	Pump-houses	165,000		
	Pumps, etc	430,000		
	Distribution and control circuits	44,000		
		$739,000		
	Engineering and contingencies	148,000	887,000	2,873,000

Well Equipment

At each well there would be erected a small pump-house equipped with induction motor, control board, and pump, as shown on Sheet 79, Acc. 5307. Owing to the variation in the capacity of the wells and in the head against which the pumps would operate, the motor capacities would range from 15 to 50 H.P. each.

Telephone System

A complete telephone system is proposed for the entire system, to facilitate its operation. The cost is estimated as follows:

			Total
Development 1	$4,200		
Engineering and contingencies	800	**$5,000**	**$5,000**
Development 2	1,600		
Engineering and contingencies	400	**2,000**	**7,000**
Development 3	3,400		
Engineering and contingencies	600	**4,000**	**11,000**
Development 4	800		
Engineering and contingencies	200	**1,000**	**12,000**
Development 5	2,500		
Engineering and contingencies	500	**3,000**	**15,000**

Total Cost

The total cost of the power-station, transmission and distribution, at each stage of development, is presented in the following table:

Stage of Development	Power-House	Trans-mission Line	Distribution Exclusive of Wells	Tele-phone System	Totals Including Allowance for Engineering and Contingencies
1	$1,218,000	$142,000	$533,000	$5,000	**$1,898,000**
2	1,476,000	208,000	1,089,000	7,000	**2,780,000**
3	1,606,000	321,000	1,744,000	11,000	**3,682,000**
4	1,606,000	358,000	1,986,000	12,000	**3,962,000**
5	1,736,000	408,000	2,873,000	15,000	**5,032,000**

COST OF POWER

For comparison with the cost of operating the proposed collecting works with other pumping systems, and for com-

parison with the cost of pumping at the existing stations of the Ridgewood system of the Brooklyn works, estimates have been prepared on the cost of power from the electrical system here proposed, considering the cost of labor, fuel, supplies, maintenance, depreciation and an allowance for interest and sinking fund.

Cost of Labor

The estimated number of employees and the annual payroll for each stage of development are as follows:

DEVELOPMENTS

	1		2		3		4		5	
	No.	Total Salaries	No.	Total Salaries	No.	Total Salaries	No.	Total Salaries	No.	Total Salaries
Chief Engineer.	1	$3,000	1	$3,000	1	$3,000	1	$3,000	1	$3,000
Assistant Engineer....	1	2,000	1	2,000	1	2,000	1	2,000	1	2,000
Assistant Engineer....	1	2,000	1	2,000	1	2,000	1	2,000	1	2,000
Station Chief...	3	5,400	3	5,400	3	5,400	3	5,400	3	5,400
Switchboard men........	3	3,600	3	3,600	3	3,600	3	3,600	3	3,600
Machinist.....	2	2,400	2	2,400	4	4,800	4	4,800	4	4,800
Machinist's helper.......	1	750	1	750	2	1,500	2	1,500	2	1,500
Enginemen....	4	4,800	4	4,800	7	8,400	7	8,400	7	8,400
Oilers.........	3	2,700	3	2,700	4	3,600	4	3,600	6	5,400
Blacksmith....	1	1,350	1	1,350	1	1,350	1	1,350	1	1,350
Blacksmith's helper.......	..	....	..	....	1	900	1	900	1	900
Carpenter.....	1	1,350	1	1,350	2	2,700	2	2,700	2	2,700
Painter........	1	1,200	1	1,200	1	1,200	2	2,400	2	2,400
Line foreman...	2	2,400	2	2,400	3	3,600	3	3,600	4	4,800
Linemen......	6	5,400	8	7,200	12	10,800	12	10,800	16	14,400
Water tenders..	3	2,700	3	2,700	6	5,400	6	5,400	9	8,100
Laborers......	6	5,400	6	5,400	8	7,200	8	7,200	10	9,000
SUBSTATIONS										
Operators.....	9	10,800	15	18,000	18	21,600	21	25,200	21	25,200
Patrolmen.....	9	8,100	15	13,500	18	16,200	21	18,900	21	18,900
Totals...	**57**	**$65,350**	**71**	**$79,750**	**96**	**$105,250**	**103**	**$112,750**	**115**	**$123,850**

In addition to the above an additional allowance of $1,000 per mile of line has been made in final summary of cost of operation for labor on repairs and maintenance of well system, which is not included here.

Cost of Coal

The cost of power generation is based on all rail anthracite coal at Patchogue, at $5.10 per long ton (tide-water coal should be somewhat cheaper than this), and a boiler and engine duty of 2.22 pounds coal per brake horse-power hour. The combined efficiency of that part of the system extending from engine shaft to water in each well is estimated as 33.4 per cent. The percentages of efficiency of the several parts

of the system on which is based this combined efficiency are shown below:

	Average Operation Per cent.	Maximum Pumpage of System Per cent.
Generator	92	92
Transformers	97	97
Transmission	92	91
Distribution	95	92
Motors	90	90
Pump	47.5	50
Combined efficiency	33.4	33.4

The amount and cost of coal required for the average pumping on each development, including water for all local uses, is estimated as follows:

Development	Average Pumpage Million Gallons Daily	Amount of Coal in Long Tons 2240 Pounds	Cost of This Coal at $5.10 per Ton
1	80	11,000	$56,000
2	165	26,250	134,000
3	236	42,250	216,000
4	266	58,500*	300,000
5	266	60,500*	310,000**

*A consumption of 10,000 tons of coal at the central power-station is estimated for pumping the Peconic Valley supply over the hill to Westhampton. This is charged to transportation and is not included here

**Estimate assumes that branch lines would on the average be operated only one year in ten

Maintenance and Supply

The yearly maintenance and supply expense for each development is taken as one per cent. of the total cost of that development.

Extraordinary Repairs and Depreciation

The depreciation of the system is computed in detail in the final summaries of cost of the works. The percentage allowances made on each portion of the works are as follows: buildings, two per cent. a year; equipment, 3.5 per cent. a year.

Taxes

An assessment of one per cent. each year is allowed on all land, and 1.5 per cent. on all structures above ground.

Total Cost of Operation

In Table 27, the several items of operating expense, which have been estimated above, are tabulated, and the fixed charges on the cost of the works computed. From the total annual expenditures the cost for each million gallons pumped has been estimated and then the average cost per million foot-gallons. These costs include all buildings and equipment, but no land or water damages.

Evidently the pumping of the proposed Suffolk County supply by this system would cost from $8 to $10 per million gallons, and the cost per million-gallon foot would range from 20 cents to 33 cents. The cost per million foot-gallons on the basis of operating expenses alone without depreciation would be only 11 cents to 16 cents.

Basis of Estimates of Cost

The details and unit prices adopted for the above transmission and distribution lines are as follows:

Transmission Line

COST PER MILE OF POLE LINE		
18 reinforced concrete poles at $140.00	$2,520.00	
108 2,500-V Insulators " .60	64.80	
108 pins " .40	43.20	
Stringing cables	275.00	$2,903.00
COST PER MILE OF DOUBLE CIRCUIT		
20,400 pounds No. 0000 copper cable at $0.17½		3,580.00
16,200 " No. 000 " " " .17½		2,820.00
12,700 " No. 00 " " " .17½		2,240.00
10,100 " No. 0 " " " .17½		1,770.00
8,000 " No. 1 " " " .17½		1,360.00
4,000 " No. 4 " " " .17½		700.00
MILES OF LINE ERECTED UNDER EACH DEVELOPMENT		
Development 1	9.7 miles No. 0000 cable; 9.3 " No. 0 "; 3.1 " No. 4 "	
" 2	8.5 " No. 0000 "	
" 3	7.6 " No. 0000 "; 4 " No. 000 "; 4.2 " No. 00 "	
" 4	6 " No. 00 "	
" 5	3 " No. 0 "; 3.4 " No 1 "; 3.8 " No. 4 "	
COST PER MILE OF DOUBLE CIRCUIT		
950 pounds No. 8 Monnot wire at $0.14½	$138.00	
72 insulators and pins " .04	2.80	
Erection	50.00	190.80
PUMP-HOUSES		
44.2 cubic yards concrete at $15	$663.00	
1 Manhole cover	100.00	
Door and incidental fittings	45.00	808.00

PUMP-HOUSE EQUIPMENT		
Pump, casing and shaft, bearing and elbow complete..	800.00	
13-foot 6-inch pipe	12.00	
1 meter	375.00	
1 stop valve	20.00	
1 gate	40.00	
Installation, wiring and incidentals	200.00	1,447.00
FOR MOTORS AND CONTROL ADD:		
50-H.P. motors	$900.00	
35 " "	750.00	
20 and 25-H.P. motors	575.00	
10 " 15 " "	475.00	

Distribution Line

COST OF POLE LINES PER MILE		
40 reinforced concrete poles at $35	$1,400.00	1,400.00
COST OF DOUBLE CIRCUIT PER MILE		
3,200 pounds No. 5 copper wire at $0.16½	$528.00	
108 insulators and pins	10.00	
Erection	150.00	688.00
AVERAGE COST OF CONTROL CIRCUIT PER MILE PER WIRE		
105 pounds No. 12 copper wire at $0.16½	$17.00	
18 insulators and pins	3.00	
Erection	13.00	33.00

Engineering and Contingencies

To the above prices there has been 20 per cent. added for engineering and contingencies.

AIR-LIFT SYSTEM

For comparison with the estimates on a system of electrically driven pumps, made by Mr. Carpenter, a brief study has been made of an air-lift system operated from compressor stations at intervals of 8 to 10 miles along the proposed aqueduct. There is little to guide one in designing an air-lift system for works of the magnitude of those proposed in Suffolk county; the preliminary studies do not encourage a more extended investigation. It is believed that the preliminary designs, on which these estimates of cost herewith given are based, are, on the whole, reasonable and that the results are sufficiently accurate for present purposes.

Compressor Stations

The location of the proposed compressor stations are shown on Sheet 72, Acc. L 621. Seven stations are laid out. Stations 1 to 4 would be located on the Montauk division of the Long Island railroad, where coal could readily be deliv-

TABLE 27

Cost of Operation

Item	Development 1	2	3	4	5
Total cost of works at each stage of development...............	$1,898,000	$2,780,000	$3,682,000	$3,962,000	$5,032,000
Average daily pumpage, million gallons, including water for local uses.	80	165	236	266	266
Total annual yield of works in million gallons	29,200	60,225	86,140	97,090	97,090
	Annual	Charges on	Works		
Operating					
Labor...............	$65,350	$79,750	$105,250	$112,750	$123,950
Coal...............	56,000	134,000	216,000	300,000	310,000
Maintenance and Supplies..............	18,980	27,800	36,820	39,620	50,320
Total operating cost, exclusive of depreciation	**$140,330**	**$241,550**	**$358,070**	**$452,370**	**$484,270**
Extraordinary repairs and depreciation.........	47,980	78,490	110,560	120,660	161,090
Total cost of operation..	**$188,310**	**$320,040**	**$468,630**	**$573,030**	**$645,360**
Cost of pumping per million foot-gallons...	0.2121	0.1518	0.1384	0.1545	0.1621
Fixed Charges					
Taxes and special assessments..........	$11,720	$12,920	$14,520	$15,220	$16,140
Interest at 4 per cent..	75,920	111,200	147,280	158,480	201,280
Sinking fund, 3 per cent., in 50 years...	16,840	24,660	32,660	35,140	44,630
Total fixed charges.....	**$104,480**	**$148,780**	**$194,460**	**$208,840**	**$262,050**
Total annual expenses, fixed charges and operating cost...........	**$292,790**	**$468,820**	**$663,090**	**$781,870**	**$907,410**
Cost per million gallons..	$10.02	$7.78	$7.70	$8.06	$9.35
Average lift in feet.....	30.4	35.0	39.4	38.2	41.0
Cost per million gallons raised one foot.......	$0.330	$0.223	$0.196	$0.211	$0.228

ered to them, and Stations 5 to 7, for the same reason, would be placed near the Main line of this railroad.

Stations 1, 2 and 3 would be near the junctions of the branch lines; the first two could furnish air for the lower portions of the Melville and Connetquot branches; the last station, 3, might operate the entire Carman's branch, as well as the wells either side of these stations on the main line. Station 4 would provide power for the easterly portion of the main line, and Station 5 the collecting works in the Peconic valley. At the latter station, there would also be an equipment of centrifugal pumps for lifting the Peconic Valley supply over the hill to the south shore aqueduct. Stations 6 and 7 are proposed on the upper portions of the Melville and Connetquot branches respectively, where the lifts are higher and the air pressures greater than on the westerly portion of the main line.

For purposes of estimate, a compressor unit of 500 H.P. has been assumed for these stations. This is larger than commonly used in this country, but the proposed stations would be large permanent plants, not temporary construction works, nor small stations in which air-compressors are ordinarily installed. One compressor unit over and above the equipment for maximum capacity has been added at each station for reserve.

The total length for collecting works operated from each of these compressor stations, the maximum pumpage and lift and the total horse-power of the equipment at each station, are presented in Table 28.

Power Transmission

From each compressor station on the main line it is proposed to lay two parallel air mains to the wells on either side, each of which would carry sufficient air with a station pressure of 60 pounds per square inch to operate the wells in the section served at their average rate of pumpage. Ordinarily only one of these two parallel pipes would be in active use; the other would be under greater pressure for the purpose of starting a well or in order to pump a few of them somewhat deeper than others. The second would, therefore, be in reserve and could be used when repairs were being made to the other. By raising the pressure in both lines, sufficient air could be delivered to the wells of any section for the maximum pumpage.

TABLE 28

Air-Lift Equipment

Station or Section Number	Total Length of Section in Miles	Maximum Yield in Million Gallons Daily	Maximum Lift in Feet	Total Volume Required of Free Air in Cubic Feet per Minute at Each Successive Stage	Corresponding Horsepower at Each Stage	Total Horsepower of Equipment Including Reserve
		FIRST STAGE, NASSAU COUNTY TO GREAT RIVER				
1.........	12.48	103	43	26,500	3,560	4,000
2.........	2.22	18	46	4,750	640	1,500
Total...	**14.70**	**121**	**44**	**31,250**	**4,200**	**5,500**
		ADDITIONAL SECOND STAGE, GREAT RIVER TO SOUTH HAVEN				
2.........	13.56	106	51	29,810	4,000	4,000
3.........	1.28	13	56	3,990	550	1,500
Additional.	**14.84**	**119**	**52**	**33,800**	**4,550**	**5,500**
		ADDITIONAL THIRD STAGE, SOUTH HAVEN TO QUOGUE				
3.........	9.53	68	57	20,320	2,750	2,500
4.........	9.36	40	64	12,640	1,750	2,500
Additional.	**18.89**	**108**	**60**	**32,960**	**4,500**	**5,000**
		ADDITIONAL FOURTH STAGE, PECONIC VALLEY BRANCH				
5.........	4.28	50	45	13,200	1,800	2,500
		ADDITIONAL FIFTH STAGE, BRANCH LINES				
6.........	6.63	40	110	16,400	3,000	3,500
7.........	7.95	35	90	13,120	2,400	3,000
3.........	9.37	32	80	11,400	2,100	3,000
Additional.	**23.95**	**107**	**90**	**40,920**	**7,500**	**9,500**
Total...	**76.66**	...	...	**152,130**	**22,550**	**28,000**

The air mains on the branch lines would likewise be in duplicate, but each would be sufficient for the maximum pumpage of the system. The two mains would be placed in one trench well below the frost line to avoid freezing. The air mains have been designed on the usual formulæ for flow of air in pipes. In no case would a velocity of 30 feet per second be exceeded, and the average delivery of the system would not require a greater velocity than 20 feet per second. The greatest distance over which air would be transmitted in these estimates is about eight miles, which is well within the distances used in natural gas practice. No allowance has been made in the estimates for loss of air in transmission; experience in the natural gas fields in western Pennsylvania indicates that the loss of gas through the leakage of the high-pressure lines is very small when the pipes are properly laid.

The number of wells is estimated as in electrically operated pumping system, page 335.

Pumping Units

On Sheet 73, Acc. L 622, is a study of a pumping unit for a large stovepipe well. This shows the arrangement proposed for the casing, the air mains, valves and connections, also the chamber for removing the air discharged with the water, the enclosing manhole and the connections to the aqueduct.

It should be noted that except for the valves and the meter, there are no moving parts in this unit to get out of order, and that the depreciation would, consequently, be small. The manhole covers should be water-tight at the ground line and arranged so as to be securely locked. The ventilator is necessary to permit the air from separating chamber to escape to the atmosphere.

Cost of Pumping System

The total cost of an air-lift system for each stage of development is given in the table below:

Development	Estimated Cost	Allowance for Engineering and Contingencies 20 Per cent.	Additional for this Development	Totals
1	$796,060	$159,212	....	$955,272
2	926,860	185,372	$1,112,232	2,067,504
3	816,210	163,242	979,452	3,046,956
4	444,480	88,896	533,376	3,580,332
5	1,619,060	323,812	1,942,872	5,523,204

SHEET 73

Cost of Operating Works

The annual expenditures on the air-lift pumping system, on the completion of the fourth stage of development, are estimated in the table below. The operating cost is based on the proposed average delivery of the works of 266 million gallons per day, on an average lift of 40 feet, which would require 9,000 H. P. at the compressors, a slightly greater lift than the average for the electrical system, to allow for head lost in separating air and water before the discharge into the aqueduct.

COST OF OPERATION AT FOURTH STAGE OF OPERATION

OPERATING			
Power cost, 9,000 x $65	$585,000		
Line cost, estimated 52.7 miles x $1,000	52,700		
Extraordinary repairs and depreciation	132,400		
Total			$770,100
Cost per million foot-gallons		$0.20	
FIXED CHARGES			
Interest on $3,580,332 at 4 per cent			$143,200
Sinking fund, 50 years, at 3 per cent. (0.887 per cent. per year), on $3,580,332			31,800
Taxes and special assessments			6,270
Total fixed charges			$178,900
Total annual expenditures, fixed charges and operating expenses			$949,000
Total cost per million gallons (365 x 266 = $97,090)		$9.78	
Total cost per million foot-gallons on average lift of 40 feet		.25	

Basis of Estimates

There is little published data on the efficiency of the air-lift system, and much of the experiments available have been made on smaller wells than those proposed for the Suffolk County works. On Sheet 74, Acc. L 672, is plotted the results of some experiments on the amount of air necessary to pump a gallon of water one foot high. The curve taken from a published pamphlet of the Bacon Air Lift Company appears to be reasonable in view of the results obtained by this Board at the Babylon experiment station. It should be noted, however, that the quantities of air per minute in this diagram corresponding to a gallon of water represent the results obtained by the best regulation of the air supply, and equally good results are not given by other authorities. The efficiency naturally falls off when a greater air pressure than that for the best efficiency is used. This is most important, because it would hardly be possible in a system comprising a large num-

ber of wells of different depths, extending four to five miles either side of a compressor station, to regulate the pressure at all wells so as to secure the best economy. A higher pressure than that corresponding to the best economy would probably be maintained in order to avoid interruption in pumping through momentary reductions in pressure.

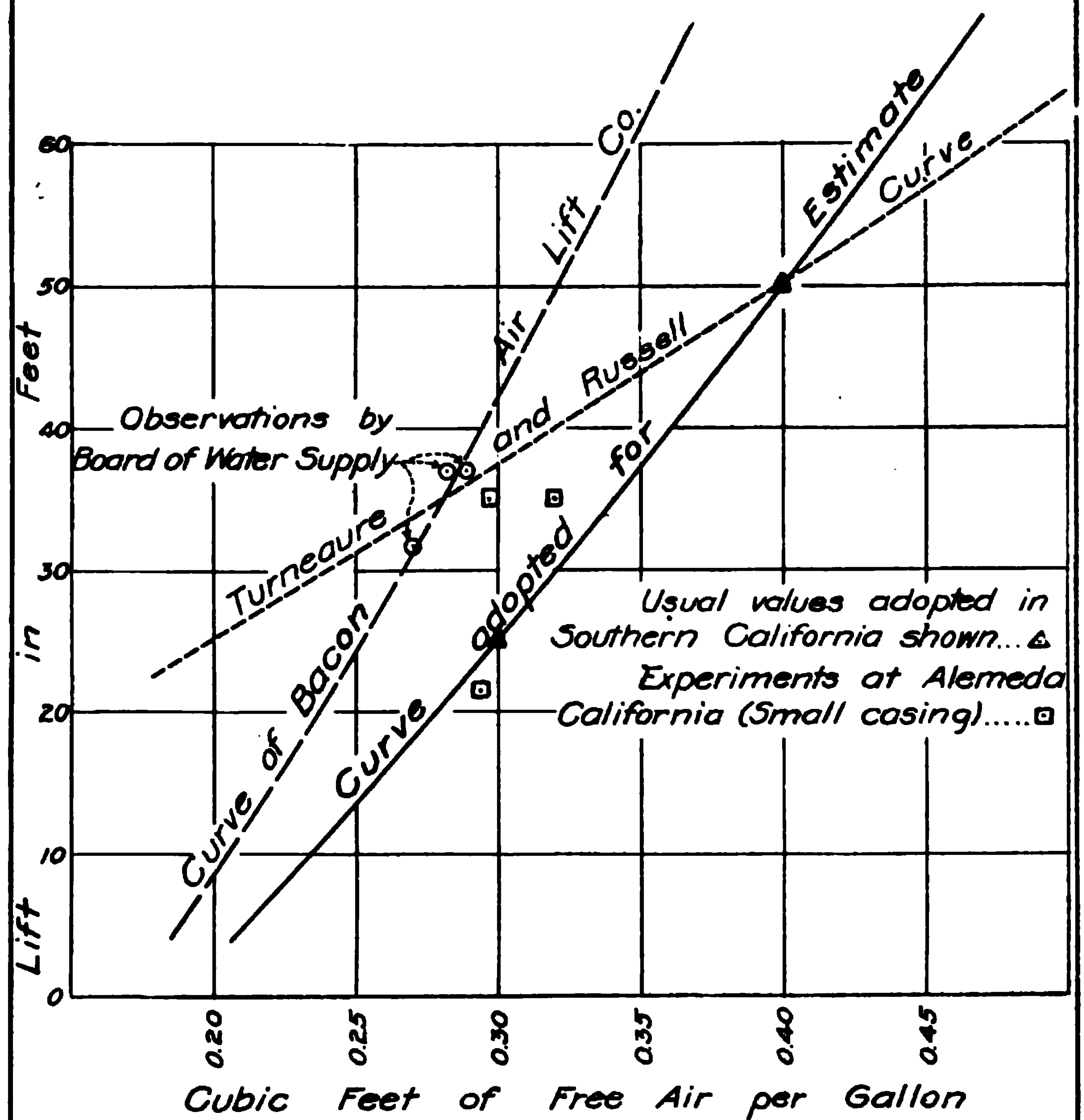
For these estimates, a line has been assumed on this diagram more in agreement with other experiments. This line, which happens to fall on the Alameda observations, is 20 per cent. in excess of the Bacon air-lift curve; this margin is provided in order to secure a reasonably safe basis for the estimation of the actual amount of free air that would be necessary in practical operation of a large plant.

Efficiency of Air Lift

Neglecting for the moment the losses that occur in the mains and in the control valves, it is of interest to see what power is required to compress the amount of air shown in this curve as necessary to lift one gallon of water per minute through a hight of 40 feet (=0.36 cubic foot per minute), assuming submergence of 1.5 times the lift, or 60 feet, and to compare this with theoretic power.

To compress one cubic foot of free air adiabatically to the pressure corresponding to this submergence, 26 pounds per square inch require 0.0763 H. P. and 0.36 cubic foot requires 0.0274 H. P. The theoretic power necessary to raise one gallon of water 40 feet is 0.0101 H. P. and the efficiency is $\frac{0.0101}{0.0274}$ = 37 per cent. If it requires 2.5 pounds of coal for 1-H. P. hour, the duty of air lift on the above basis would be 29,000,000 foot-pounds per 100 pounds of coal.

This efficiency is probably seldom exceeded in practice. The best efficiency of any air-lift system in the vicinity of Los Angeles was placed, when first installed, at 35 per cent. and most plants run at more nearly 25 per cent. efficiency. The air-lift plant at one of the ground-water stations in the Borough of Queens gave a duty of 30,000,000 foot-pounds per 100 pounds of coal when first tested, but is now running at duty of about 20,000,000 foot-pounds, which corresponds to an efficiency of 20 to 25 per cent.



City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
AIR LIFT SYSTEM
RELATION OF LIFT AND FREE AIR
FEBRUARY 25 1908

B.W.S 525

Acc.L.672

The total efficiency of the system estimated in this report, with all the losses in the transmission and distribution of the air, is about 20 per cent., and considering the difference in conditions of yield and lift in wells on a line of four miles in length, there is small chance of a larger efficiency than this.

COMPARISON BETWEEN THE ELECTRICAL PUMPING SYSTEM AND THE AIR-LIFT SYSTEM

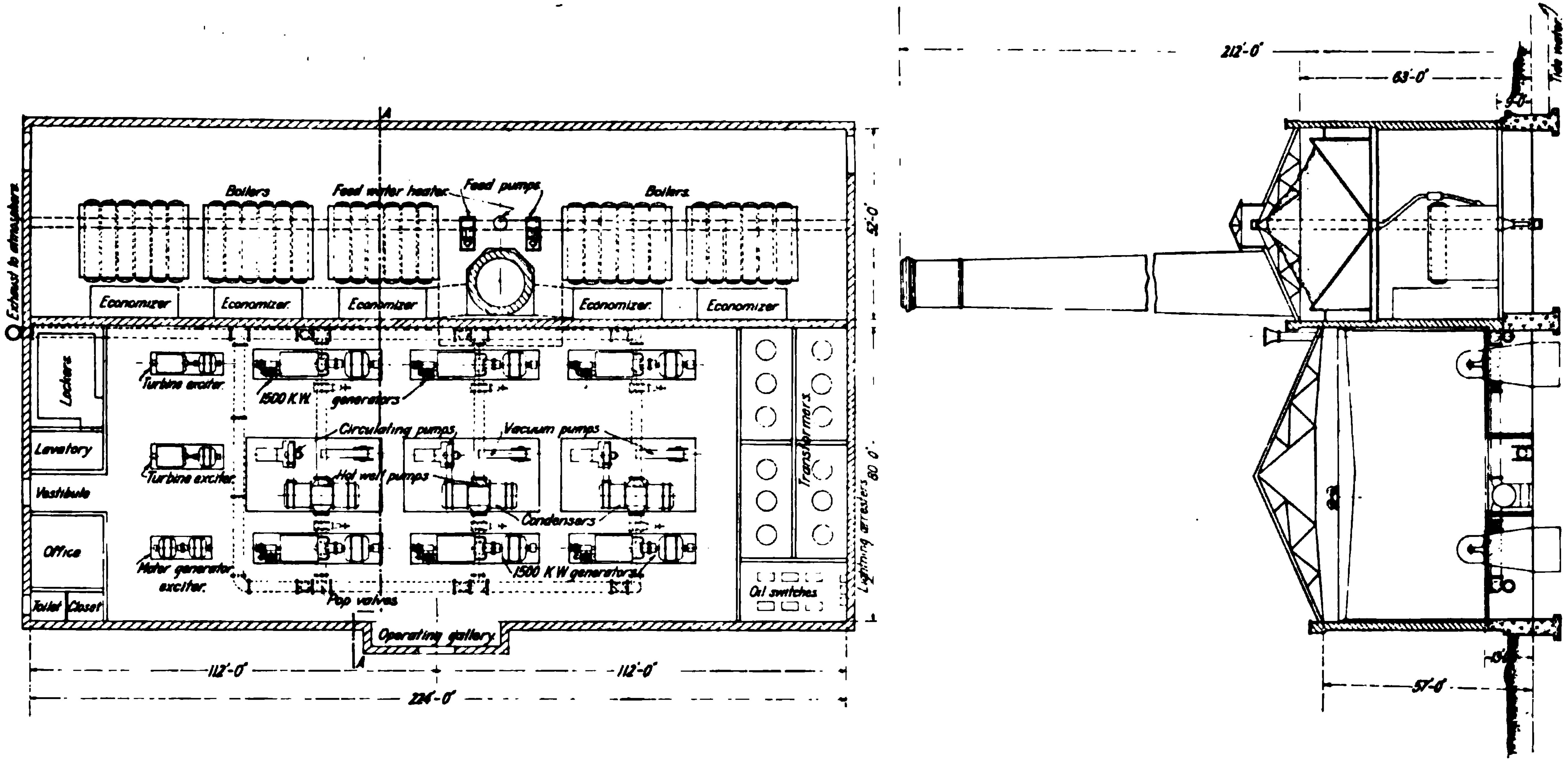
The total cost of the air-lift system estimated here is somewhat less than that of the electrical pumping system, but the lower efficiency of the air-lift makes the total operating cost of this system the larger. The comparison of the annual charges on the two systems at the completion of the fourth stage of development is as follows:

Pumping System	Total Operating Expenses	Fixed Charges	Total Annual Expenditures	Total Cost of Water per Million Gallons	Corresponding Total Cost of Pumping per Million Foot-Gallons	Total Cost of Pumping per Million Foot-Gallons exclusive of Fixed Charges
Electrical....	$573,030	$208,840	$781,870	$8.06	$0.211	$0.155
Air-lift......	770,100	178,900	949,000	9.78	0.25	0.20

The operation of the air-lift system, therefore, would be 20 per cent. more expensive than the electric pumping system.

The air lift would perhaps have one advantage in aerating the supply at each well, should it be necessary to filter any portion of the Suffolk County water. It does not, however, appear necessary to treat these waters, as there is not at present sufficient iron in the supply as a whole.

Possibly a higher efficiency could be secured with the air-lift system than estimated in this report, and perhaps a more economical arrangement of compressor stations and well units could be made, but there is no warrant in the data now available to increase the estimates on efficiency that have been adopted. There is, however, every possibility that a better efficiency may be obtained with some centrifugal or plunger pump that would perhaps make the total continued efficiency of the electrical system at least 40 per cent. instead of 33 per cent. as estimated.



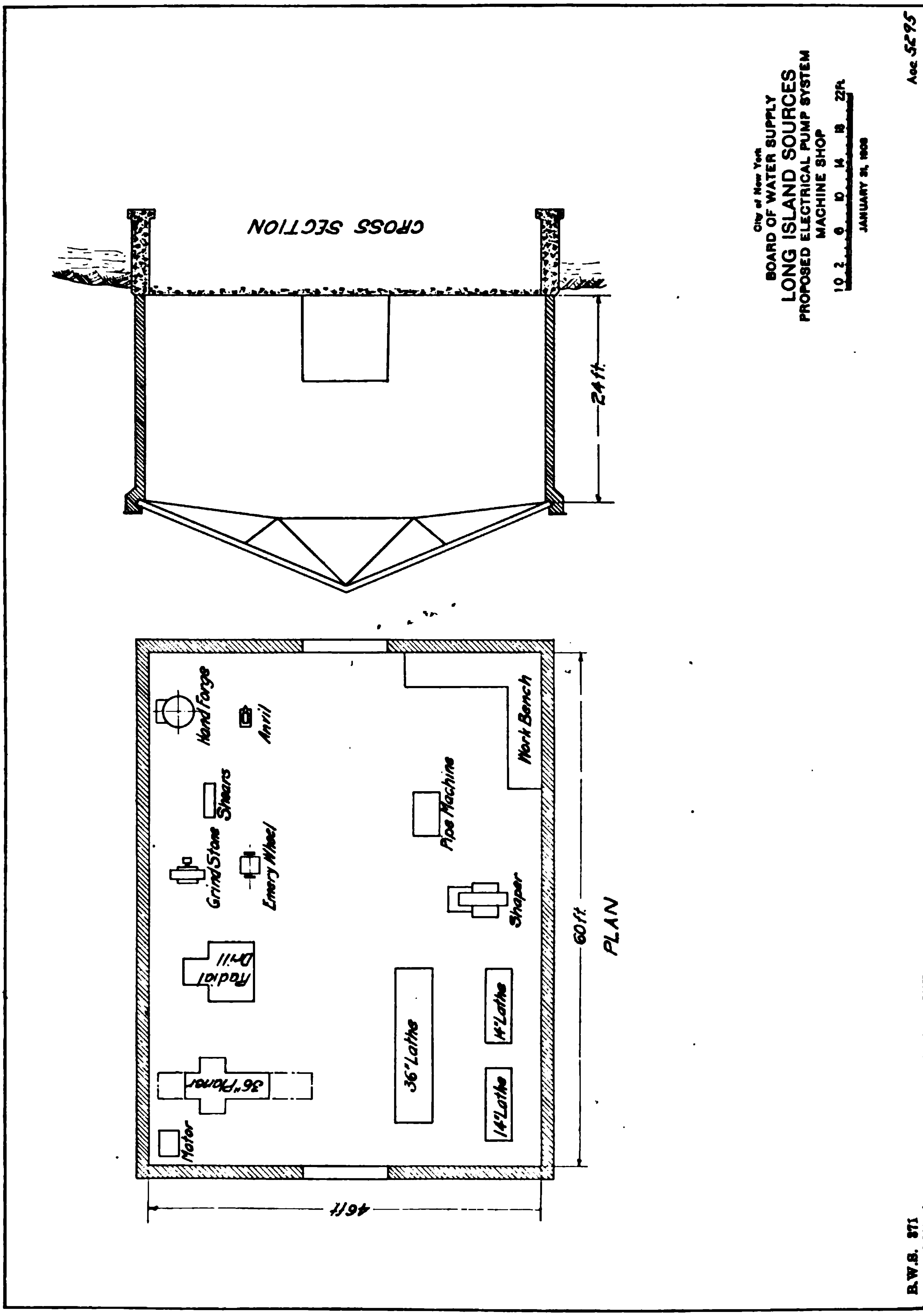
City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED ELECTRICAL PUMPING SYSTEM
POWER HOUSE

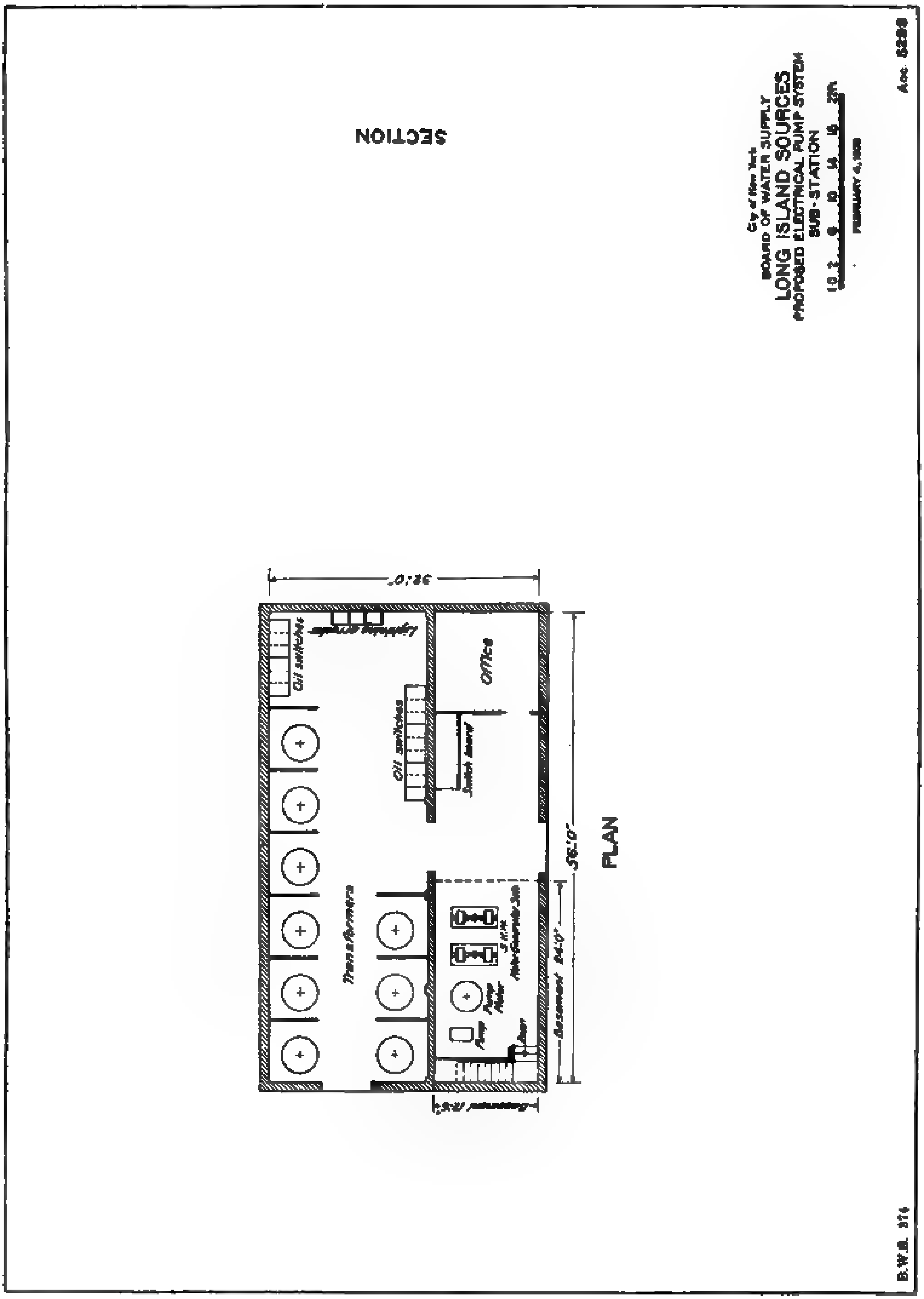
16 0 16 32 Ft

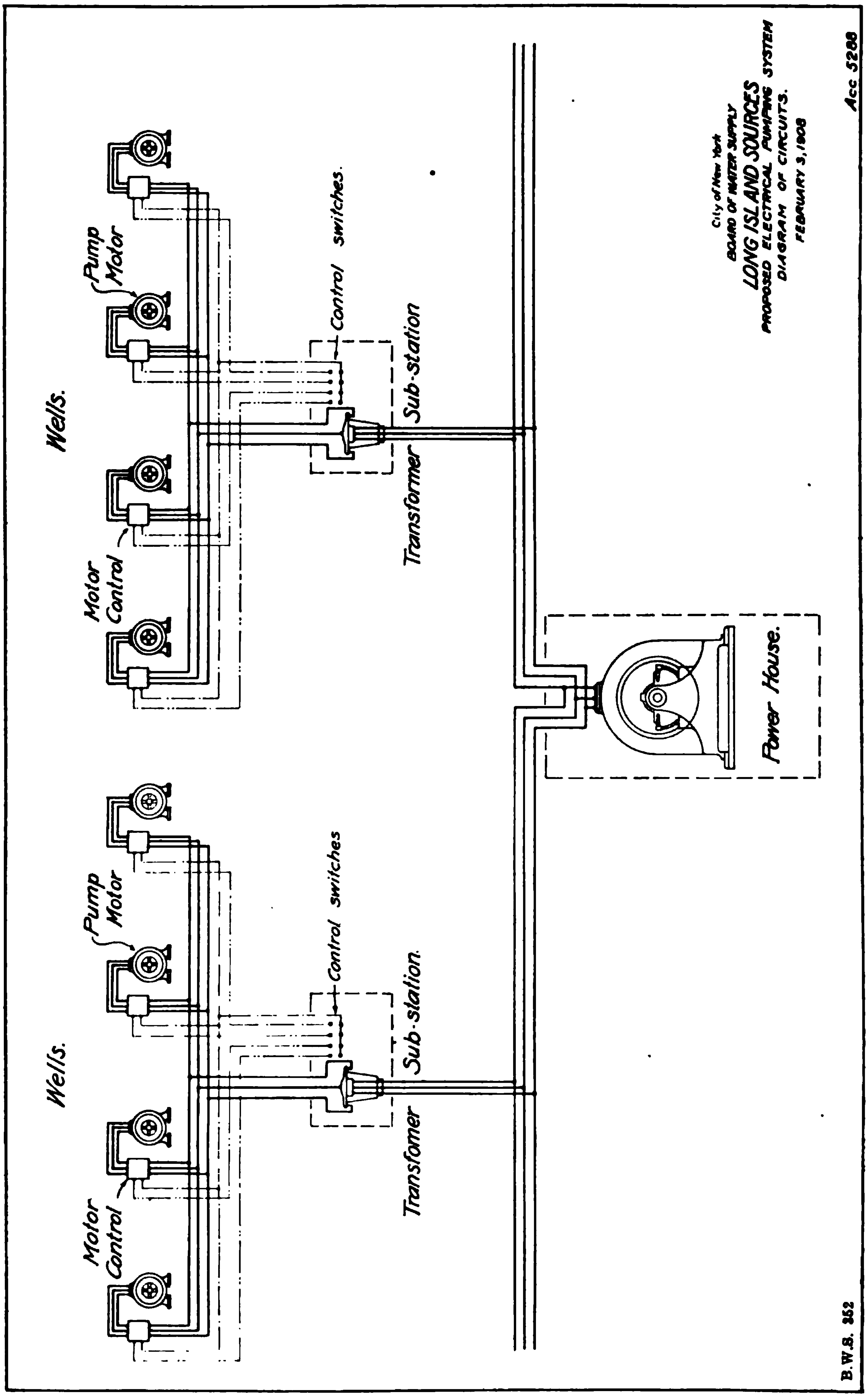
FEBRUARY 8, 1908

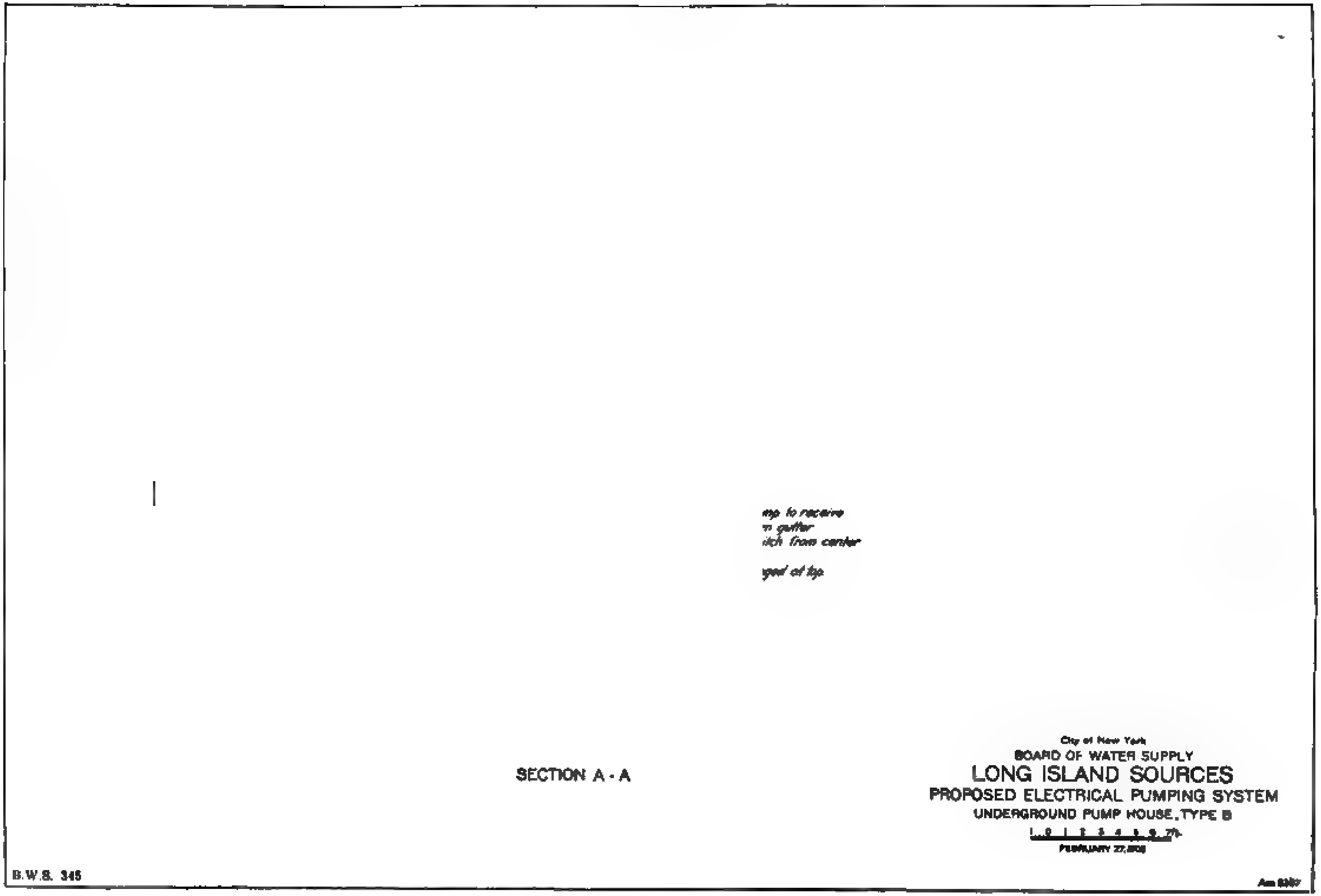
SHEET

B.W.S. 349


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED ELECTRICAL PUMP SYSTEM
MACHINE SHOP
10 2 6 10 14 18 22 Ft.
Acc 5295
CROSS SECTION
24 ft.
PLAN
60 ft.
46 ft.
Hand Forge
Anvil
Work Bench
Shears
Pipe Machine
Grind Stone
Emery Wheel
Shaper
Radial Drill
36" Lathe
14" Lathe
14" Lathe
36" Planer
Motor
B.W.S. 371


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED ELECTRICAL PUMP SYSTEM
SUB-STATION
SECTION
PLAN
Oil switches
Office
Switch board
Transformers
Pump
56'0"
Basement 24'0"
B.W.S. 314


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED ELECTRICAL PUMPING SYSTEM
DIAGRAM OF CIRCUITS.
FEBRUARY 3, 1908
Acc 5288
Wells.
Pump Motor
Motor Control
Control switches.
Sub-station
Transformer
Power House.
Wells.
Pump Motor
Motor Control
Control switches
Sub-station.
Transfomer
B.W.S. 352


mp to receive
n gutter
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SECTION A - A
City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED ELECTRICAL PUMPING SYSTEM
UNDERGROUND PUMP HOUSE, TYPE B
B.W.S. 345

APPENDIX 7

UTILIZATION OF FLOOD FLOWS OF SURFACE STREAMS

BY WALTER E. SPEAR, DIVISION ENGINEER

Sheets 8, 9 and 10, Accs. L 609, L 610 and L 611, show that the flow in the smaller Suffolk County streams, is fairly constant throughout the year; those which have an average discharge on the proposed line of collecting works of not more than four million gallons per day might in course of time entirely disappear on the line of the works for most of the year through the pumping of the wells designed to intercept the ground-waters, just as small watercourses in Nassau and Queens counties have been dried up through the operation of the wells and galleries of the Brooklyn works. There would, therefore, be but little loss of surface-water in these smaller streams, and infrequent flood flows that occur in them when the ground surface is frozen could be profitably wasted.

It should be realized that the location of the proposed collecting works well back from the shore, crosses the smaller streams where much of the flow that appears in their lower courses is still in the ground beneath them. Table 5, page 113, shows that all these smaller streams, with the exception of Sampawams creek had, in 1907, average flows from one to four million gallons per day, and the maximum discharges for short periods were but little in excess of these figures. Such portions of the flow of these streams that are not intercepted would serve to maintain the ponds below and would thus avoid the expense of pumping to keep these filled if this became necessary. The amount of water lost by failure to intercept all this surface-water would be comparatively insignificant.

In the larger streams, Carll's river, Connetquot brook, Patchogue river, Carman's river and Peconic river, the flow is less uniform than in the smaller streams; large discharges take place in the winter and spring months that could not be collected by the works planned to intercept the ground-water underflow, although the collecting works of the branch aqueducts that parallel all these streams except the Patchogue river could readily secure most of their dry weather flow, if it were permissible to do so. The flood flows of these

larger streams over and above the amount necessary to maintain the pond levels on these watercourses, or the amount of water in excess of the utilized discharge of these streams, are of no value to Suffolk county, and should so far as possible be appropriated and delivered to New York City.

AMOUNT OF SURFACE WASTE

The amount of surface-water that might have been appropriated during the year 1907 from the streams on the proposed line of the collecting works is shown below. The rainfall last year, in southern Suffolk county was but little below the normal, and these flows give a fair idea of what may be safely expected in an average rainfall year.

	Discharge of Stream in 1907 on Line of Collecting Works			Probable Average Surface Waste After Providing 5 Million Gallons Daily for Ponds and Local Needs	Probable Undeveloped Surface-Water Available after Ground-Water Works in Operation
	Average in Million Gallons per day	Maximum Million Gallons Daily	Normal Low Summer Flow Million Gallons Daily		
Carll's river..........	17.20	32	10	10	5
Connetquot brook....	32.70	42	25	25	20
Patchogue river......	9.43	15*	8**	5	3
Carman's river.......	36.20*	50*	20	25	22
Peconic river.........	14.65	27	5	10	0
Total.........	**110.18**	**166**	**68**	**75**	**50**

*Estimated from incomplete gagings
**Half of waters of Patchogue river owned by Patchogue lace-mill and the flow in next column allowed for their uses

On the basis of the gagings of 1907, a total average discharge of 75 million gallons per day could have been taken from these streams without damage to local interests. Probably, 25 million gallons or more per day could be obtained by the ground-water pumping works of the main line and branches, leaving 50 million gallons in the streams to be secured by special works. This undeveloped run-off, during an average rainfall year, would be equivalent to a discharge of 150,000 gallons per day per square mile from the whole watershed. Even during the long periods of low rainfall, probably as much as 75,000 to 100,000 gallons per day per square mile would be lost, unless works were built to utilize it. The safe unit yield of the Suffolk County watersheds is not estimated at more than 800,000 gallons per day per square

mile, so that this surface waste, amounting to, perhaps, one to two-tenths of the assumed unit yield, is too large a percentage to be neglected.

The development of these waste surface-waters during the winter and spring months, when the percolation from the rainfall is high, would allow the pumpage from the remainder of the collecting works to be diminished and the ground-water reservoirs replenished for the draft of the dry months of summer and fall.

PURIFICATION OF SURFACE-WATERS

Even though many portions of the Suffolk County drainage areas are now but sparsely populated, it would be very unwise, in view of the pollution of many of the surface-waters of the Ridgewood system in Queens and Nassau counties, to permit any surface-water to enter the proposed aqueduct without purification. This purification could be most cheaply and surely effected by the process of natural filtration through the bottoms of reservoirs or filtration basins, which would be created on these larger streams, and about which wells would be driven to deliver the surface-water to the aqueduct as "artificial ground-water." These infiltration basins would have sufficient storage capacity to impound the largest flood discharges until they could be purified.

Ground-Water Plants Near Surface Streams

Such a development of surface-water is common in this country and abroad; in fact, the infiltration galleries below the Wantagh and Massapequa supply ponds of the Brooklyn works, secure a portion of their supply through the bottom and sides of the ponds above them, and several driven-well stations of the same system derive some surface-water from similar sources.

Many of the so-called ground-water plants in Germany, which are located near ponds and streams, secure a part of their supply from these surface-waters. This is true of the works at Berlin (Tegeler See), Charlottenburg (Wannsee), Dresden, Augsburg, Wiesbaden, Hanover and elsewhere. The experience gained at these German works is most helpful in designing the proposed infiltration basins for the Suffolk County works. In the table following is shown some informa-

tion regarding seven representative German ground-water plants that draw their supply in part from surface-waters.

City	Location of Works	Name of Stream	Character of Development	Distance from Wells or Galleries to Edge of Water at Ordinary River Stage Feet	Depth of Soil Above Screen of Wells or Galleries Feet	Depth of Screen Section Below Normal Level of Stream Feet
Dresden	Saloppe	Elbe	Gallery	45	15	7
Dresden	Tolkewitz	Elbe	Wells	258	28	15
Augsburg	Hoch Ablass	Lech	Wells	400	..	..
Wiesbaden	Schierstein	Rhine	Wells	350	35	18
Hanover	Ricklingen	Ihme	Wells and gallery	150	10	..
Hanover	Grasdorf	Leine	Wells	650	20	..
Unna	Langschede	Rohr	Wells	100	16	5

It is important to note that at the Saloppe works of Dresden, the Ricklingen works of Hanover, and at Wiesbaden, the bacteria run very high in the ground-water, when the rivers flood the surface of the ground above the collecting works, but sufficient purification is obtained at other times at these plants by the passage of the water through the alluvium between the river and the galleries or wells. No similar trouble, so far as known, has been experienced at the other plants given here.

At Wiesbaden, there are other wells than those tabulated above that supply water for street sprinkling. Some of these are not over 50 feet from the Rhine and the purification is not complete at even normal stages of the river. The distance of 350 feet at which the other wells are placed is, however, sufficient except in flood times, although the material of the substrata appeared to be coarse.

Artificial Ground-Water

The subject of "artificial ground-water" has been given much attention abroad. In each one of the German works mentioned above, the development of surface-water was more or less incidental in a general scheme for intercepting the ground-water flow towards the natural watercourse; but there are many plants in Europe, particularly in Sweden, where artificial ground-water is obtained in the absence of any naturally saturated strata, by pumping or diverting surface-water to a bed of sand and gravel and intercepting it by wells or galleries at some distance from the point of application.

This method of purification is known as the "Richert System" from J. Gust. Richert, a consulting engineer of Stockholm, who has presented the subject in his monograph "Les Eaux Souterraines Artificielles." The system was developed in Sweden, where conditions are not favorable to the ordinary methods of ground-water development. Sketches of typical artificial ground-water plants from Richert are shown on Sheet 80, Acc. L 66.

Some loosening up and cleaning of the bed of the artificial reservoir or canal where the water is applied, is necessary in these plants, but this is done with less care and expense than the scraping of artificial sand filters.

PROPOSED INFILTRATION BASINS

Surveys have been made for the proposed infiltration basins on the Carll's and Patchogue rivers and preliminary plans have been prepared. The proposed basins on the Connetquot and Carman's rivers could not, however, be surveyed because of the hostile attitude of the sportsmen's clubs on whose grounds these would be located. The line of collecting works on the Peconic river parallels the streams and ponds above Riverhead and no special work would be required to make a large portion of the surface-waters there available as ground-water. It might be found necessary to clean out some of the ponds, but this need not be expensive.

Location of Infiltration Basins

The general map, Sheet 4, Acc. 5602, page 26, shows the location of these infiltration basins. Those on the Carll's and Patchogue rivers would be located immediately above the main south shore aqueduct. The best sites for those on the Connetquot and Carman's rivers appear to be on the branch aqueducts near the Main line of the Long Island railroad, the first south and the second north of this line.

The Carll's River and Patchogue River basins would be located as near the south shore as ground-water could safely be drawn, but the collecting works would readily intercept the entire flood flows of these streams. The infiltration basins on the larger streams, the Connetquot brook and Carman's river, would be farther inland where the surface topography is more favorable for the large reservoirs necessary on these streams,

From J. Gust. Richert in "Les Eaux Souterrains Artificielles."

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servoir whe
face wate
applied

Original Water

Typical Development in Sand
showing augmentation of ground water
flow by introduction of surface water.

Village of Uddevalla
showing artificial ground water
development in a pocket of sand on hillside

ells

servoir
here
rface
ater is
pplied

Gothembourg
showing artificial ground water
development under conditions producing
artesian flows

Artificial Ground Water Supply in Sweden

May 1907

B.W.S. 321

where the cost of land and construction would be smaller, and where there would be less danger from sea-water in pumping the ground-water deeply from the wells located about the infiltration basins. On both of these streams the flood flows from the watershed below the proposed infiltration basins could be collected by the wells on the main south shore line where this crosses these streams and some by the wells on the branch lines nearby.

Outline of Design for Infiltration Basins

In general, the muck that now fills the bottom of the valleys on the sites of the infiltration basins would be removed, and the sand beneath excavated to an elevation above sea-level of about 5 to 10 feet, the excavated material being placed in the dam and the aqueduct embankments. The shallow flowage around the basin would also be filled up, and the shores of the reservoir raised where necessary, and given appropriate landscape treatment. A basin having a full depth of 10 to 15 feet would generally be obtained; this would be essential to provide sufficient storage at times of large flood flow and the low elevation of the bottom would ensure a covering of water to prevent the surface of the bottom from being frozen. In addition to the filter surface in the bottom of each basin, it is also proposed to deepen and widen the stream above the basin. Observations at Massapequa have shown that flowing water prevents the stream bottoms from clogging up, and more water filters through them than through the bottoms of ponds in which there is little movement.

Wells about 500 feet apart would be driven about the margins of these basins at a distance of about 300 feet from the flow line in order that there would be sufficient thickness of sand between these wells and the bottom of the basin to secure complete purification of the surface-water.

Capacity of Infiltration Basins

The area and volume of the proposed infiltration basins are shown below. These quantities have been determined for the two basins on the Carll's and Patchogue rivers from the topographical survey maps. The approximate estimates for the Connetquot Brook and Carman's River basins have been made from the geological survey maps.

Infiltration Basins	Area of Filter Surface in Basin in Acres	Probable Maximum Flood Discharge of Stream to be Filtered Million Gallons Daily	Corresponding Maximum Rate of Filtration in Gallons per Day, per Acre	Total Storage Volume of Basin in Million Gallons
Carll's river................	51	25	490,000	167
Connetquot brook..........	100	40	400,000	300
Patchogue river............	29	10	340,000	95
Carman's river.............	100	40	400,000	300

From the maximum flood discharge of each stream, the probable rate of filtration has been estimated. The maximum rate of filtration would not, in any case, be more than 500,000 gallons per day per acre, which is but little more than one-fourth to one-sixth of the allowable rate for slow sand filtration. This rate could doubtless be maintained without any difficulty for several months without exposing the bottom of the infiltration basins for cleaning, although the same means that have been recently devised for scraping sand filters when covered with water would answer equally well for these basins. Once a year during low water flow of stream, the basin could be pumped down and thoroughly cleaned of the accumulation of silt and humus that would, in time, reduce the rate of filtration.

The extremely large run-offs from these Long Island watersheds that occur once or twice in a generation could not be impounded in any reservoir that can be constructed on these southern Suffolk County streams, and ample overflow and culvert capacity must be provided for these infiltration basins. On the basis of stream discharges observed in western Long Island in February, 1902, when a warm rain occurred on the snow covered and frozen ground, run-offs of one to three inches depth may be expected in proportion to the size of the watershed. A run-off of one inch would probably never be exceeded on such streams as the Connetquot, Carman's and Peconic rivers, but two to three inches per day might occur on the Carll's and Patchogue rivers. The loss of these occasional floods would be insignificant.

Clinton Experiments

Some interesting experiments were carried on at Clinton, Massachusetts, by the Metropolitan Water Board in 1896 and

1897, in connection with the design of the North dike of the Wachusetts reservoir. A basin, having an area of 1/20 acre, was prepared on the summit of a hill about 40 feet above Coachlace pond, and water from this pond was applied for four or five months to determine the amount of percolation through the material forming this hill. The sands, in which this basin was formed, are not unlike the yellow sands of Long Island, and the amount of water applied to this basin gives some idea of the rate of filtration that may be attained through the proposed infiltration basins in Suffolk county. The Long Island sands are, if anything, coarser than those at Clinton.

The amount of water applied during the three long periods of continuous operation are shown below. At the end of 40 or 50 days, the surface of the bed was clogged to such an extent as to require cleaning.

Approximate Period of Continuous Operation Days	Rate of Application in Gallons per Day per Acre		
	Maximum at beginning of run	Minimum at end of run	Average rate
40	2,500,000	650,000	1,100,000
55	2,000,000	850,000	1,150,000
45	2,000,000	1,000,000	1,200,000

The rate of filtration through the proposed basins in Suffolk county would not ordinarily be over 200,000 to 300,000 gallons per day per acre, and the intervals between scraping might, perhaps, be as much as three or four months. The Suffolk County waters are not silt bearing, but, of course, carry leaves and vegetable mold that form the black muck on the bottoms of the ponds. They differ but little from the waters of Coachlace pond that were used for the Clinton experiments.

The average head on the bottom of the Clinton basin was only four feet, whereas with full basins those proposed in Suffolk county may have a head of 10 to 15 feet or more, and the strata below would be continuously saturated, so that, even when clogged by several months' use, the Suffolk County basins should be able to pass 500,000 gallons per day per acre.

Cost of Infiltration Basins

The cost of each of these basins is estimated as follows:

	Carll's	Connetquot	Patchogue	Carman's
Land	203 acres $60,900	350 acres $70,000	162 acres $48,600	250 acres $62,500
Damages	Included in other estimates			
Construction of basin	178,200	200,000	82,900	100,000
Wells and equipment	37,400	85,000	34,000	51,000
Total, including allowance for engineering and contingencies	**$276,500**	**$355,000**	**$165,500**	**$213,500**

These infiltration basins would make an average supply of 50 million gallons per day available, which might not be otherwise obtained. With all the fixed charges and operating expenses, the cost of this water would not be proportionally greater than the remainder of the ground-water supply.

APPENDIX 8

REMOVAL OF IRON FROM SUFFOLK COUNTY GROUND-WATER

BY WALTER E. SPEAR, DIVISION ENGINEER

The analyses in Appendix 2 show that some of the ground-waters from the yellow sands and gravels of Suffolk county contain more iron than is allowable in a supply for domestic or commercial uses. The manganese in a few localities is also somewhat high, but the data now available does not indicate that the amount of either iron or manganese in the whole supply, when all the waters are mixed together, would be above the safe limits that are usually fixed.

Iron and manganese give much trouble in water-supplies through the encouragement of growths of certain organisms, which cause unpleasant tastes and odors in the water. These organisms, with the oxides of these metals, sometimes fill up the wells of the collecting works and connections, or the pipes of the distributing system. Waters containing but a small percentage of iron give much annoyance in the laundry, even if the amount is not sensible to the taste, and such waters cannot often be used for some manufacturing purposes. The iron can be readily removed from the water by exposure and aeration, and by rapid filtration through sand or gravel. Unfortunately, the manganese does not as readily precipitate and cannot be easily removed.

Iron in the Ridgewood Supply

The Ridgewood supply contains nearly 0.6 of a part of iron per million, which is somewhat greater than is considered advisable. The limit is usually placed at about 0.4 to 0.5 of a part. This amount of iron in the Ridgewood supply has resulted from the greater development, during the past few years, of the ground-waters in the westerly portion of the old watershed that are highly impregnated with iron. While 0.6 of a part per million would not warrant any large expenditures for iron removal plants on the Ridgewood works, in laying out a new system in Suffolk county, the possibility of filtering a portion of it must be considered.

Iron Removal Plants in Suffolk County

It is not unlikely that it would be advisable in the future to remove the iron from some of the ground-waters in Suffolk county, that contain iron greatly in excess of that allowable for the whole supply. This should be done at small plants where the waters could be treated before they enter the main aqueduct. It is possible that the entire supply from the Peconic valley would be filtered, and the pumping-station near Riverhead should be planned with a view to treating at this point all the water delivered by the aqueduct there. The iron removal plants on Long Island, and those of ground-water supplies from similar formations in New Jersey, indicate that the iron in these yellow gravels is in such a form as to be readily precipitated by brief contact with the atmosphere, through falling a few feet in the air, through exposure in open reservoirs, or even through the introduction of air into the suction mains.

The proper treatment of ground-waters for the removal of iron must, however, be determined for each locality. When the time comes to treat portions of the Suffolk County supply, sufficient investigation must be made to learn the amount of aeration and the rate of filtration for each water.

German Iron Removal Plants

Many of the German ground-waters have required very thorough aeration by flowing in thin sheets or slowly dropping through a stack of coke, brick, or thin wood slabs. Two types of aerators employed in Germany are shown on Sheets 81, 82 and 83, Accs. L 71, L 67 and L 68, and some data on the aerators and filters of the principal iron removal plants in northern Europe are presented in Table 29. It will be noted in these German filters, that maximum rates of 25 million gallons per acre per day are sometimes employed and that 12 or 15 million gallons per acre is not uncommon. The highest rate is not probably desirable, as it requires more frequent cleaning of the filters.

The iron removal plant at Leipsic is interesting because of the absence of the aerators common in other German plants and the coarse material of which the filters are made. (See Sheet 84, Acc. L 65.) The water is delivered to these filters through 6.5 miles of aqueduct and siphon and a short

overfall as at the plant of the Queens County Water Co. on Long Island, at Far Rockaway, New York. The iron appears in large flocculent masses that permit of rapid filtration.

In other plants in Germany, where the iron is not so readily precipitated, the water falls through the aerators and reaches the filters in much finer particles. This breaking up of the iron particles makes filtration more difficult and the treatment of a water before filtration is therefore important.

TABLE 29

THE REMOVAL OF IRON FROM GROUND WATER SUPPLIES

CITY	LOCATION OF SOURCE OF SUPPLY	METHOD OF DEVELOPING GROUND WATER	PUMPING SYSTEM	AMOUNT OF SUPPLY IN 1904 MILLION GALLONS PER DAY	AERATION OF WATER: METHOD OF AERATION	MATERIAL OF WHICH AERATORS ARE FORMED	HEIGHT THROUGH WHICH WATER FALLS OR FLOWS FEET	AREA OF UPPER SURFACE OF AERATOR SQ. FT.	NORMAL RATE OF FLOW THROUGH AERATORS MIL. GALS PER DAY PER ACRE OF UPPER SURFACE	TOTAL SURFACE IN AERATOR ON WHICH WATER IS EXPOSED SQ. FT.	NORMAL RATE OF FLOW GALLONS PER DAY PER SQ. FT OF SURFACE	FILTRATION OF WATER: TOTAL AREA OF FILTER ACRES	MAX RATE OF FILTRATION MIL GAL PER ACRE PER DAY	DEPTH OF BODY OF FILTER IN FEET	DEPTH OF WATER ON FILTER IN FEET	LOSS OF HEAD IN FILTER FEET	MATERIAL COMPOSING BODY OF FILTER	SIZE OF MATERIAL OF FILTER: APPROX. DIAM MILLIMETER	EFF. SIZE	UNIFORM CO-EFF.	AMOUNT OF IRON IN PARTS PER MILLION: RAW WATER	WATER AFTER AERATION AND FILTERING
EUROPEAN SUPPLIES																						
BERLIN	TEGELERSEE	WELLS	RECIPROCATING STEAM PUMPING ENGINES	22.7	EXPOSURE IN THIN FILM IN FLOW THROUGH AERATOR AND IN BASIN BELOW	STACK OF PINE WOOD SLABS ON EDGE	DEPTH OF AERATOR = 9.8 FALLS 3FT MORE IN AIR	8800	115	1844000	12.4	10.0	25.7	3.9	4.3	—	MEDIUM SAND	—	0.38	1.6	1.3	TRACE
CHARLOTTENBURG	WANNSEE	"	"	13.2	"	STACK OF BRICKS ON EDGE	DEPTH OF AERATOR = 11.5 FALLS FEW MORE FEET IN AIR	2750	123	217000	37.4	0.99	25.7	3.3	3.1	—	"	—	0.40	2.3	1.8	—
LEIPSIC	NAUNHOF	"	"	16.0	EXPOSURE OF 50 MIN. IN AQUEDUCT AND SHORT TIME ON COVERED FILTERS	—	—	—	—	—	—	6.92	18.2	6.6	4.6	1.6	FINE GRAVEL	AVERAGE 6.	—	—	3.5	TRACE
HANOVER	RICLINGEN	INFILTRATION GALLERIES AND WELLS	"	5.3	NO APPARENT AERATION	—	—	—	—	—	—	0.013	640.	6.6	—	—	BEECH WOOD SHAVING	—	—	—	0.4	0.2
AMSTERDAM	DUNES NEAR HAARLEM	OPEN CANALS DEEP WELLS	GRAVITY RECIPROCATING STEAM PUMP	7.9	EXPOSURE IN CANAL WELL WATERS SPRAYED THROUGH HORIZONTAL PERFERATED PIPES	—	WELL WATER RISES IN JETS ABOUT 3FT. FALLS ABOUT 7-8 FT.	—	—	—	—	5.76	2.1	3.8	3.3	2.0	FINE DUNE SAND	—	0.17	1.6	4.0 [illegible] 0.7 AT FILTERS	0
THE HAGUE	DUNES	INFILTRATION GALLERIES	GRAVITY	5.1	EXPOSURE IN OPEN CANAL LEADING FROM GALLERIES	—	NOT KNOWN	—	—	—	—	4.32	2.6	3.1	2.8	6.6?	FINE DUNE SAND	—	0.19	1.6	ABOUT 5.	1.1
TILBURG HOLLAND	NEAR TILBURG	WELLS	RECIPROCATING STEAM PUMPING ENGINES	2.0	EXPOSURE IN FLOW THROUGH COKE TOWER	COKE	DEPTH OF AERATOR 10FT. FALL IN AIR SEVERAL FEET MORE	1180	119	ROUGHLY 116000	ROUGHLY 27.2	0.19	15.4	2.0	3.3	—	FINE SAND	—	0.15	1.9	2.6	0.36
AMERICAN SUPPLIES																						
FAR * ROCKAWAY	—	WELLS	RECIPROCATING STEAM PUMPING ENGINES	—	EXPOSURE IN FALLING SAY 3 FT. OVER BELLMOUTH AND ON SURFACE OF OPEN FILTER	—	ABOUT 3 FT. IN AIR	—	—	—	—	0.92	9.0	3.0	2.0	—	MEDIUM SAND	—	—	—	2.57	0.01
REDBANK* N.J.	—	"	"	—	EXPOSURE IN JETS FROM VERTICAL PIPE AND SURFACE OF OPEN FILTERS	—	ABOUT 3 FT. IN AIR	—	—	—	—	0.035	13.6	3.0	2.5	—	BEACH SAND	—	—	—	—	—
ASBURY* PARK	—	"	PNEUMATIC AIR LIFT	—	EXPOSURE IN RESERVOIR AFTER DELIVERY BY AIR LIFT	—	—	—	—	—	—	—	—	—	—	—	CONTINENTAL PRESSURE FILTER	—	—	—	—	—

* MOST OF THIS DATA FROM ALLEN HAZEN'S "FILTRATION OF PUBLIC WATER SUPPLIES"

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Capacity of works 22.7 Mil Gals. per day.
Plant at Tegelersee is in two parts. Each has an aerator equipment for precipitating iron in ground water before filtration.
Both plants contain 20 units each of 4 rows of 1‹

Constructed in 1902 after failure of coke stack.
Designed by Director Beer of Berlin Water works

of 10 stacks
feeding

Grouping of Aerators
Berlin, Tegelersee Works

Acc. L 71

Maximum rate of aeration is 115 Mil. Gals. per acre per day over superficial area of aerators or 12.4 gallons per day per square foot of interior surface over which water slowly trickles to bottom. Amount of iron 1.3 per mil.

Constructed in 1902, after failure of coke stack.
Designed by Director Beer of Berlin Water Works.

acity of Tegel
rks = 22.7 Mil.
als. per day.

Distributors or
mall troughs, 2¾"
quare, deliver water
o stack over notches
t top.

Aerators are
aned by increas-
the flow to one
w of stacks to
times the normal
few minutes only
equired to wash
t stacks.

are 10 stacks in row and 4 rows to a
unit (See Section of aerator house.)
In both plants at Tegelersee there are

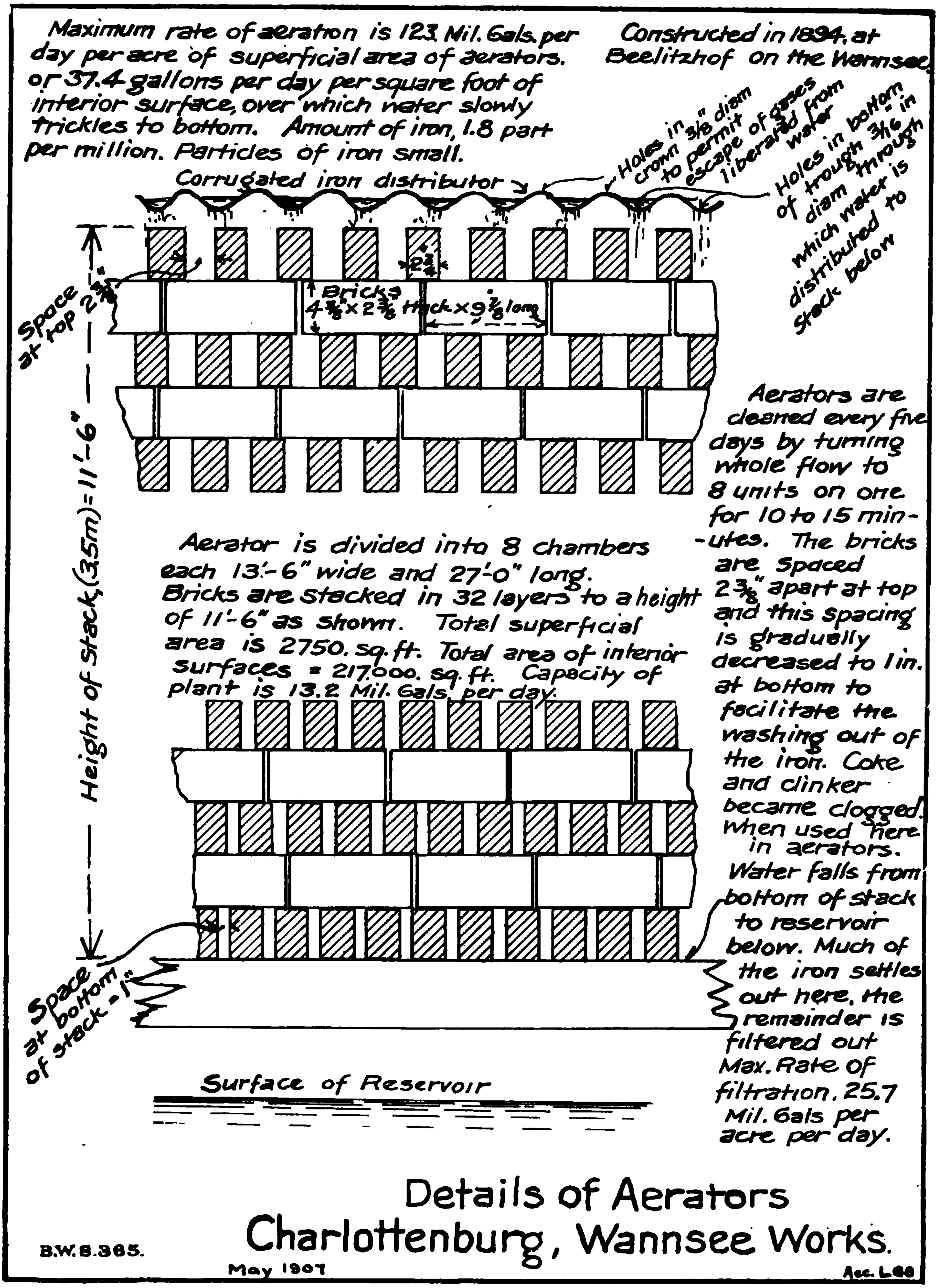
of st

Water falls from
ottom of stack
to reservoir below
distance of
3.3 ft. Much iron
ettles out here
emainder is
ltered out at
aximum rate of
25.7 Mil. Gals per
acre per day.

Surface of Reservoir

Details of Aerators
Berlin, Tegelersee Works

May 1907. B.W.B. 359 Acc. L.67


Maximum rate of aeration is 123 Mil. Gals. per day per acre of superficial area of aerators. or 37.4 gallons per day per square foot of interior surface, over which water slowly trickles to bottom. Amount of iron, 1.8 part per million. Particles of iron small.
Constructed in 1894, at Beelitzhof on the Wannsee.
Corrugated iron distributor
Holes in 3/8" diam crown to permit of gases to escape liberated from water
Holes in bottom of trough 3/16" in diam through which water is distributed to stack below
Space at top 2 3/8"
2 3/4"
Bricks 4 7/8 x 2 3/8 thick x 9 7/8 long
Height of Stack, (3.5m) = 11'-6"
Aerators are cleaned every five days by turning whole flow to 8 units on one for 10 to 15 minutes. The bricks are spaced 2 3/8" apart at top and this spacing is gradually decreased to 1 in. at bottom to facilitate the washing out of the iron. Coke and clinker became clogged when used here in aerators.
Aerator is divided into 8 chambers each 13'-6" wide and 27'-0" long. Bricks are stacked in 32 layers to a height of 11'-6" as shown. Total superficial area is 2750. sq. ft. Total area of interior surfaces = 217,000. sq. ft. Capacity of plant is 13.2 Mil. Gals. per day.
Water falls from bottom of stack to reservoir below. Much of the iron settles out here, the remainder is filtered out. Max. Rate of filtration, 25.7 Mil. Gals per acre per day.
Space at bottom of stack = 1"
Surface of Reservoir
Details of Aerators
Charlottenburg, Wannsee Works.
B.W.S.365.
May 1907
Acc. L88

SHEET 84

Filters are divided into 14 chambers, each 20 ft. wide and 110 ft. long. Total Area = 6.92 Acres.
Depth of filter of fine gravel, ⅛" to ⅜" diam = 6.6 ft.
Depth of water on filter = 4.6 ft.
Normal loss of head in filter = 1.6 ft.
Volume of supply filtered = 16. Mil. Gals per day.
Maximum rate of filtration = 18. Mil. Gals per day per acre.

Water from wells not aerated beyond exposure in 6.4 miles of aqueduct and siphon and in overfall at filters. Iron appears in large flakes.

Amount of iron in water before filtration = 3.5 parts per million; after filtration only a trace.

Constructed at Stötteritz, near Leipsic, in 1894 for removal of iron in Naunhof ground water supply. Engineer Thiem.

Section of Filters
Scale abt. 8 feet to an Inch.

B.W.S. 110

Filters of Iron Removal Plant
Leipsic

May 1907

Acc. L65

APPENDIX 9

FRESH-WATER RESERVOIRS ON SALT-WATER ESTUARIES, TO PROTECT COLLECTING WORKS FROM THE SEA-WATER

BY WALTER E. SPEAR, DIVISION ENGINEER

The main south shore line of the proposed Suffolk County collecting works cannot, everywhere, be located back of the 20-foot or even the 15-foot ground-water contour, where it has been shown in Appendix 2 that the works would be safe from the infiltration of sea-water. To secure such a location at the crossings of the deeper valleys, would necessitate wide detours back into the island, which would greatly increase the length and cost of the aqueduct and would reduce the tributary catchment area.

Safety against the entrance of sea-water could, however, be secured in these valleys where the ground-water is but a few feet above the sea, by constructing dams across the outlets of the salt-water estuaries of the streams and creating fresh-water reservoirs that would crowd out the sea-water in the underlying gravels. Artificial ponds have already been created through private effort on many streams in southern Suffolk county, that provide the necessary protection to the proposed ground-water collecting works, just as Massapequa lake, originally a private pond, protects a portion of the Brooklyn works in Nassau county. No additional works need be constructed on such streams, which include most of the creeks on the first 20 miles of the Suffolk County shore. There are, however, about 14 streams, mostly in eastern Suffolk county, on which fresh-water reservoirs should be constructed.

Limiting Distance to Salt Water

In general, no sea-water should be permitted within the probable line of inflection of the water-table toward the wells, which represents the southerly limit of the catchment area; otherwise, the salt water would flow at once to the wells. When the collecting works are in full operation, the ground-water would sometimes be inflected toward the works for a distance of 3000 to 5000 feet south of the proposed aqueduct line. For the proper protection of the supply, the sea-water in the surface channels must, however, be crowded consid-

erably beyond these distances to prevent its reaching through the open channels, the line of inflection toward the wells, and wide bodies of fresh water should be permanently interposed. The dams on these proposed fresh-water reservoirs should, therefore, for safety, be built at least 2000 feet beyond this line of inflection of the ground-water, or from 5000 to 8000 feet south of the proposed aqueduct and the collecting works. The larger figure, say 1½ miles, has generally been secured in laying out the proposed reservoirs. The location for the dams would naturally be fixed by the topography of the channels and the elevation of the adjacent lands, and some of them on the smaller streams have been laid out only 7000 feet, and in one case only 6600 feet from the collecting works. Salt water on the Patchogue river would be even nearer, (5200 feet), after the completion of a small dam at the head of the harbor on Division street, but the fresh water in Patchogue lake, which stands at Elevation 11, and that in West lake, would assist in crowding the sea-water back.

The distance from the collecting works through which it is proposed to remove the salt water on each stream is shown in the table following:

Name of Stream	Present Distance of Salt Water South from Line of Collecting Works Feet	Distance of Salt Water in Feet South of Collecting Works After Completion of Proposed Reservoirs
Connetquot river	1,400	11,400
Browns creek	4,500	8,500
Patchogue river	3,400	5,200
Swan river	3,500	8,800
Mud creek	4,300	8,000
Carman's river	1,100 north	8,300
Forge river	3,800	9,700
Old Neck creek	4,700	7,000
Terrell river	4,500	7,500
Seatuck creek	3,800	7,000
East branch	3,600	8,000
Speonk river	5,700	8,500
Beaverdam creek	2,900	6,600
Quantuck creek	3,200	7,000

Hight of Proposed Reservoirs

Each reservoir surface should be as high as possible above mean sea-level in the south shore bays, in order to provide the greatest protection for the ground-water collecting works. Many limitations in the hight of the surfaces of these reservoirs exist in low banks, highways, culverts and bridges, and most important of all is the difficulty of maintaining the reservoirs without artificial pumping.

A flow line of two feet above mean sea-level would probably be high enough if the strata below were uniformly porous, because two feet of fresh water would balance a depth of brackish water equivalent to the full depth of the yellow water bearing gravels, if the brackish water had a specific gravity of 1.015 to 1.025. Where possible, however, a hight of three feet is proposed for greater safety, because the deep water gravels do not everywhere communicate freely with the surface.

Location of Reservoirs

The locations of the proposed reservoirs are shown on the general map, Sheet 4, Acc. 5602, page 26. With the exception of the small reservoir proposed on the Patchogue river, plans of all reservoirs have been prepared from the topographical surveys made by the engineers of this Board.

Design of Proposed Dam

An earth embankment is proposed for these reservoirs which could be made of the material dredged from the river channels. This material would be pumped and deposited on either side of a center line of sheet piling, which would be capped above the water-line with concrete. The proposed section of one of these embankments, that on the Connetquot river, is shown on Sheet 85, Acc. L 479, which exhibits also the concrete spillway and the lock and railway for small boats that would be provided on the larger and navigable streams, Brown's creek, Carman's river, Forge river and Seatuck creek. The reservoir dams on the other and smaller streams would be equipped with spillways only, although several of them could, if required, be provided at small expense with railways for small boats.

Maintenance of Dams and Reservoirs

These reservoirs would be maintained in the same manner as the City parks and would form a most attractive feature of these Suffolk County streams, and at the same time would greatly improve navigation for all craft. Except for the larger dams where locks should be provided, there would be no cost for operation beyond the occasional visits of laborers to cut the grass and repair the embankment slopes. The few reservoirs whose surfaces would need be maintained artificially will be considered in a subsequent appendix.

Cost of Reservoirs

The estimated cost of these reservoirs is shown in the following table. While these reservoirs would improve the lands about them, some interruption in the natural drainage would result from their construction, and a liberal allowance has been made in the estimates for damages and ample land takings have been provided for.

Reservoir	Construction	Land and Consequential Damages	Total Exclusive of Engineering and Contingencies
Connetquot river.......	$76,900	$52,000	$128,900
Browns creek...........	18,700	37,000	55,700
Patchogue creek........	8,000	7,000	15,000
Swan river.............	30,600	32,000	62,600
Mud creek..............	19,400	20,000	39,400
Carman's river.........	44,500	92,000	136,500
Forge river............	69,500	42,000	111,500
Old Neck creek.........	23,100	6,000	29,100
Terrell river..........	36,200	12,500	48,700
Seatuck creek..........	59,900	22,300	82,200
East branch............	18,200	11,000	29,200
Speonk river...........	14,400	12,500	26,900
Beaverdam creek........	10,800	13,200	24,000
Quantuck creek.........	16,700	12,600	29,300
Total...........	**$446,900**	**$372,100**	**$819,000**

An allowance of 20 per cent. is made in final summary of cost of these works for engineering and contingencies.

Basis of Estimates

The quantities on which the above reservoir costs were made up have been estimated liberally, and land and damages are equally large. The unit prices adopted are as follows:

Excavation on embankment and sites.....	$0.25 per cubic yard
Excavation on spillway and lock sites....	.50 per cubic yard
Embankments	.25 per cubic yard
(It is assumed that most of the earth would be handled by pump dredges)	
Soil dressing	.75 per cubic yard
Concrete masonry of locks and spillways..	12.00 per cubic yard
Concrete paving on embankments.......	6.00 per cubic yard
Round piles on main embankment, in place	.25 per foot
Round piles for coffer-dam, in place.....	.35 per foot
Lumber sheeting in place..............	65.00 per M ft. B. M.
Lumber walings in place..............	60.00 per M ft. B. M.
Lumber for foot bridges and docks.....	50.00 per M ft. B. M.

duct from the proposed pumping-station in Brooklyn borough to the extreme easterly end of the south shore development. The surface topography of Long Island from Ridgewood to Quogue is, fortunately, very favorable to this plan, because the land surface at any given distance from the south shore increases in hight toward the easterly end of the island.

A continuous gravity aqueduct would avoid any pumping along the line of the aqueduct, as at the Millburn pumping-station of the Brooklyn works, where the supply collected in the "new conduit" is lifted about seven feet into the "old conduit" running to Ridgewood, or pumped through cast-iron pipe to this station. The low elevations of the ground on the line of the "new conduit" near the Long Island railroad, made this arrangement necessary. It could have been avoided by moving the aqueduct and supply ponds back from the shore, but the works were built to collect a surface supply, and were necessarily located near the south shore where the flow in the surface streams is a maximum.

The City, through the Department of Water Supply, now owns a strip of land generally 200 feet in width just south of the "old conduit" and the Montauk division of the Long Island railroad, from a point a short distance east of the Ridgewood station to Clear stream. The 72-inch steel-pipe line is located on this land, but there is ample room for the proposed Suffolk County aqueduct without interfering with this pipe-line or with the driven-well stations and infiltration galleries that are being constructed there. From Clear stream it is now proposed to cross over to the north side of the Long Island railroad, and locate the aqueduct as far as the Suffolk County line at some distance north of the railroad and the south shore villages, where the ground is higher than on the line of the Ridgewood works, and an economical cut-and-cover section could be built.

A wide strip of land may be purchased this year by the Department of Water Supply along the south side of the Long Island railroad for the extension of the 72-inch steel-pipe line from Clear stream to Massapequa, and the proposed Suffolk County aqueduct might well be constructed within it as far as the Millburn reservoir. This alternative line is shown on the general map as a dotted red line. Beyond Millburn reservoir the aqueduct would, of necessity, cross to the north side of the railroad, because the location proposed

by the department on the south side of the railroad is too low for a cut-and-cover section.

Siphons

It would not be feasible to construct the proposed Suffolk County aqueduct entirely of a masonry cut-and-cover section on the hydraulic gradient. Siphons would be necessary in the main aqueduct at Great River, South Haven, Eastport, Westhampton, and again at Valley Stream should the alternative line in Nassau county be adopted. Those in Suffolk county would avoid high embankments. The Valley Stream siphon would be necessary to avoid interference with street grades in a thickly settled suburban district; the pressure in this siphon would be small, and a concrete section slightly reinforced could be adopted. The siphons in Suffolk county at Great River, South Haven and Eastport, would be constructed in deep valley crossings, where a detour to secure a cut-and-cover location would be impossible, and the pressures would be so high as to require riveted steel pipe. The small siphon at Westhampton, and several others of small dimensions on the branch aqueducts would be of cast-iron pipe.

Capacity of Aqueduct

It is proposed to make the nominal capacity of the aqueduct from Suffolk county to Brooklyn borough 250 million gallons per day, which is sufficient to carry the normal safe yield of the Suffolk County watersheds. From Hempstead pond or Smiths pond to New York City, however, the ground is favorable for a somewhat greater slope in the aqueduct than farther east, and it would be possible, with the same aqueduct section, to increase the nominal capacity to 300 million gallons per day. This excess capacity is proposed with a view to transporting, in time of great need, a large volume of storage through a branch aqueduct from the Hempstead storage reservoir, and the additional capacity would also serve to occasionally convey all the water carried by the old Brooklyn conduit, so that the latter could be emptied for cleaning and repairs.

The old conduit was built of brick masonry 50 years ago, and inspection has shown the need of thorough repairs, which cannot at present be made because this conduit could not be out of service for a sufficient length of time without cutting off the supply of Brooklyn borough.

The full section of 250 million gallons daily capacity need not be carried into Suffolk county farther than Great River, 15 miles from the Nassau County line. The capacity beyond this point would be roughly proportional to the area and yield of the tributary watershed. On Sheet 97, Acc. L 605, are presented mass curves of the average yield of Suffolk County watersheds and the proposed nominal capacity of the main aqueduct. The excess capacity of the aqueduct in eastern Suffolk county varies from 40 to 60 million gallons daily over the average yield. This is provided to permit these easterly portions of the watershed to be drawn upon to their maximum capacity, when, through accident or design, the westerly portions of the collecting works were not being operated. Changes in section are generally made at the junction of the branch lines to permit the full discharge of these laterals to be delivered. The capacity of the Peconic aqueduct is planned for the maximum yield of the tributary watershed, 50 million gallons per day.

The branch lines have been designed for a nominal capacity of 40 to 50 million gallons per day, which represent the probable maximum delivery of the collecting works on these lines.

Excess Capacity of Aqueducts

Using a value of C in the Chezy formula of 120, the capacity of each aqueduct section was computed for a flow four to five per cent. larger than the capacity given. The nominal capacity of each section represents, therefore, the probable safe carrying capacity of the aqueducts after several years of service without cleaning, when the bottom would perhaps be covered with sand pumped in with water from the wells.

It would not be unreasonable to expect a coefficient of 130 or even 140 if the aqueduct were properly cleaned every six months or every year, and with this value of C, the main aqueduct to Ridgewood could transport the maximum delivery of the watershed of 300 million gallons per day in times of great demand. Only by giving the main aqueduct to the City a capacity considerably in excess of the normal yield of the watershed, may a large covered distributing reservoir in Brooklyn borough be dispensed with, and the cheap groundwater storage in the sands of southern Long Island made available. With the connection proposed to Brooklyn from

Hill View reservoir for the Catskill supply an excess of 20 per cent. in the capacity of the Suffolk County aqueduct above that corresponding to the average supply from Suffolk county should be sufficient.

Size and Grades of Aqueducts

The sections of the Suffolk County aqueduct have been designed after the type of concrete masonry aqueduct now being constructed for the Catskill works, with some modifications in the relative hight and width which seem desirable for Suffolk County conditions.

The widths and hights of the aqueduct sections corresponding to the capacity selected are shown on Sheet 97, Acc. L 605, above referred to. The details of these sections, with the proposed widths and slopes of excavation and embankment, are presented on Sheets 98 to 102, inclusive, Accs. LJ 133, L 594, L 606, L 331 and L 593.

No section in wet earth is provided in these type sections, as it is planned to excavate and construct the aqueduct, for most of its length, in dry trench. It is proposed, where the subgrade is below the surface of the ground-water, to lower the water-table below this grade during construction, by temporary driven wells. These wells, spaced 200 to 300 feet apart along the aqueduct line, would be driven and pumped by portable plants into completed sections of the aqueduct, or into flumes that would transport the water a thousand feet or more beyond the work. In Suffolk county, the permanent wells might be constructed in advance of aqueduct construction, and intermediate wells of temporary character driven where necessary.

For the estimates in dry earth, an excavation on 1 to 1 slope is assumed. The aqueduct would, however, be constructed in sheeted trench for several short sections, from Pitkin avenue, Brooklyn, to the Ridgewood pumping-station, through the more thickly settled portions of Freeport, Amityville, at all railroad crossings, and at some important highways. Should the southerly alternative line be adopted in Nassau county, the aqueduct through the villages of Valley Stream and Rockville Center would be similarly constructed. In Brooklyn borough and within some of the larger villages of Nassau county, the work would necessarily be done in wet

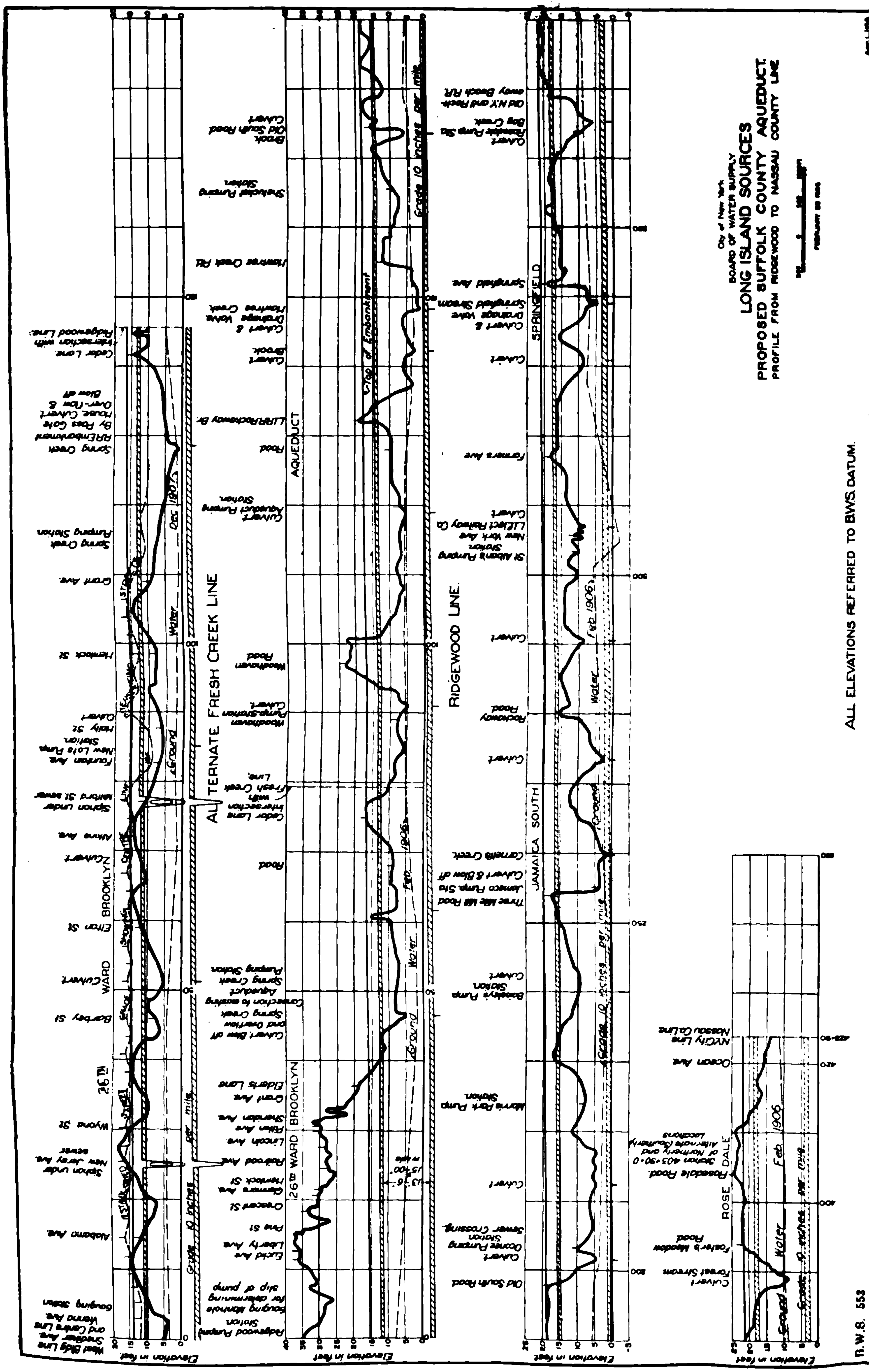
trench, and timber platforms and a central drainage system adopted.

The general plan of constructing the aqueduct in dry trench is not only the most economical one, but it would avoid the use of lumber in the foundations of the aqueduct and other structures. This is most desirable, because the ground-water surface would be frequently drawn below the bottom of the aqueducts by the proposed collecting works in Suffolk county and by the present pumping-stations in Nassau and Queens, and the life of wood foundations would be consequently short.

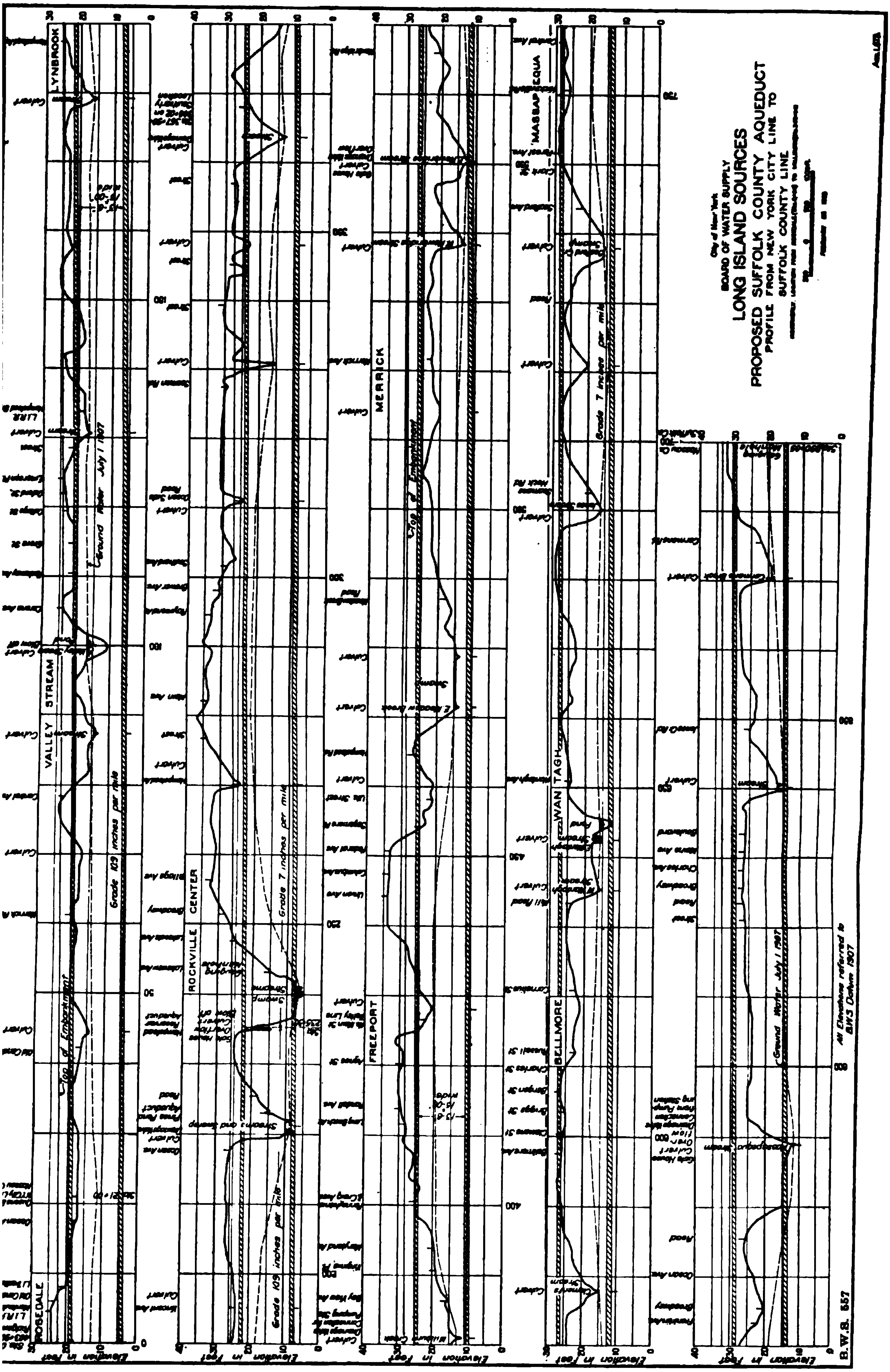
A cover of three feet on the aqueduct appears sufficient to protect the concrete section from the frost and heat, and preserve the equable temperature of the water. The slopes of 1 on 1¾ are believed to be perfectly safe with the coarse, sandy material that would be used, but it might be desirable to increase this slope to 1 on 3 or to even 1 on 5, where there is an excess of excavation, both to render the embankments more attractive and to make the grass grow better. The proposed depth of soil cover of 12 inches cannot perhaps be obtained from the stripping of the excavation in some localities without using a portion of the subsoil, and it will require much care and a great deal of sprinkling to establish and maintain a good sod on some of these soils. Special study is required to determine the best means of increasing the fineness of these soils to make them more retentive of moisture.

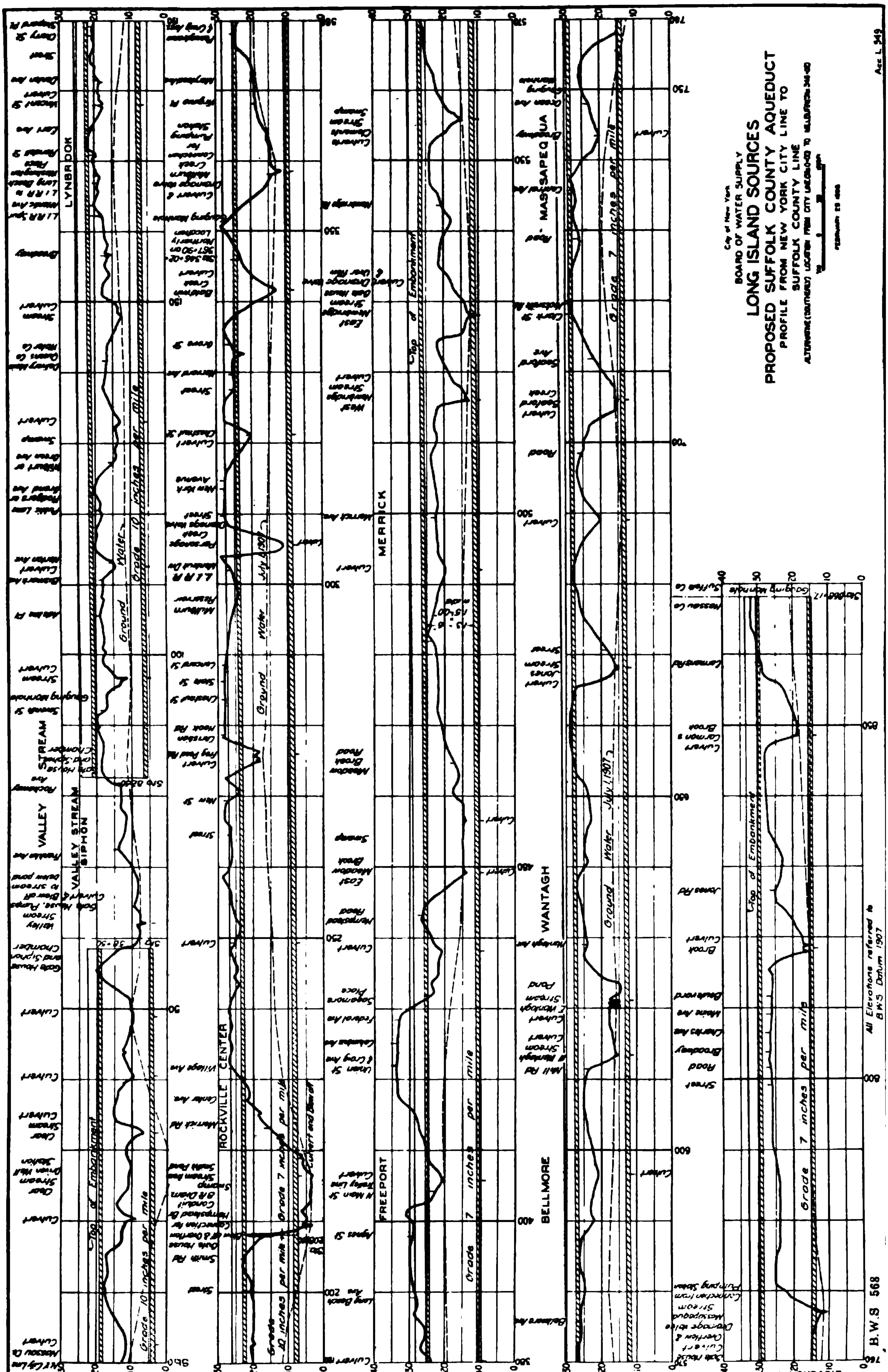
Profiles of Aqueducts

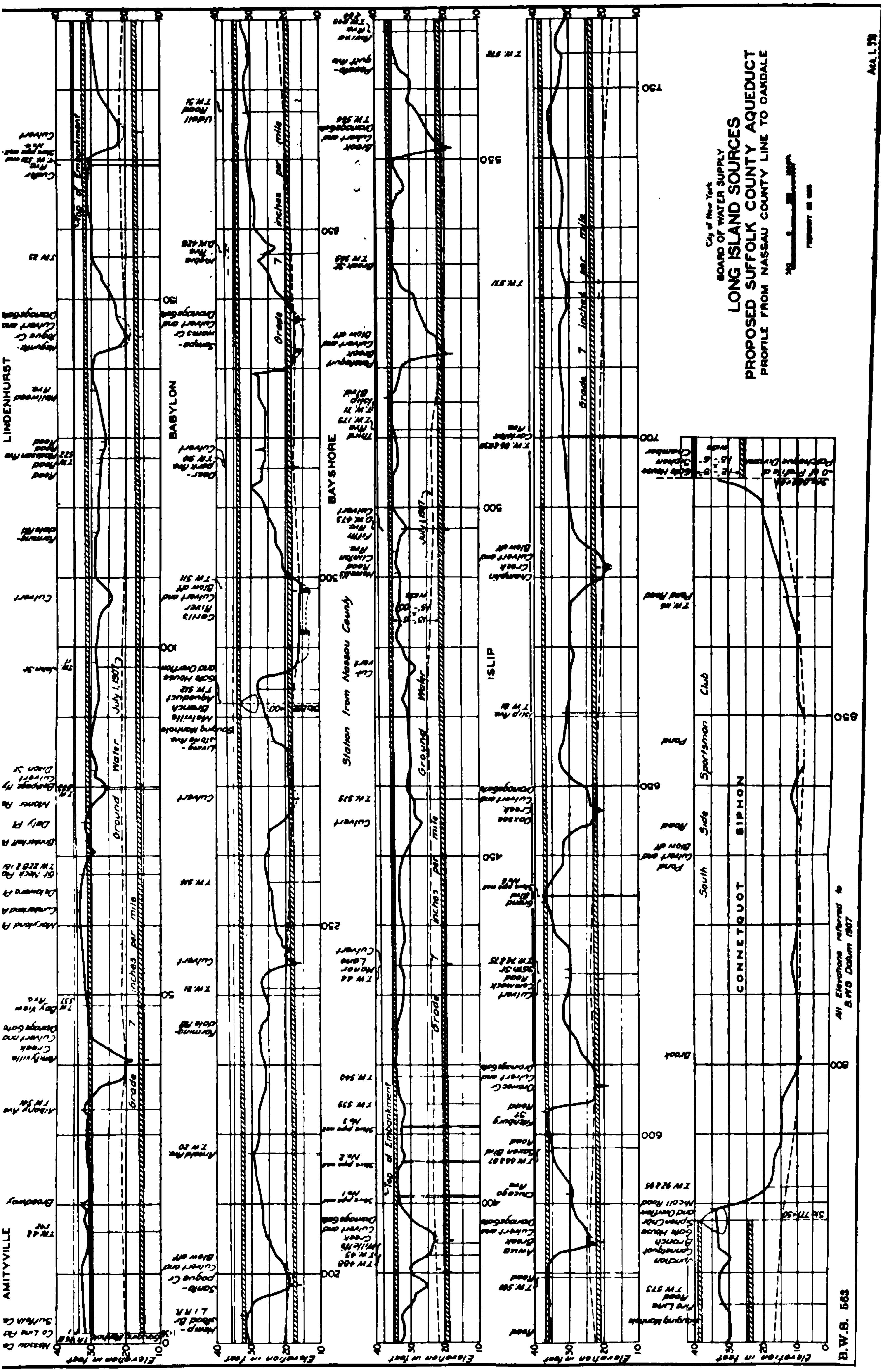
The gradients of the Suffolk County aqueduct and the elevation of the invert and crown relative to the surface of the ground and to the water-table, are shown in profiles on Sheets 86 to 96, inclusive, Accs. LJ 108, L 673, L 549, L 550, L 537, L 588, L 589, L 612, L 590, L 591 and L 340. In laying out these gradients, several conditions had to be met. Having decided upon a system of pumping all the wells throughout the proposed collecting works in Suffolk county, it appeared desirable to construct the aqueduct as economically as possible, and, to this end, to place it at such a grade that the amount of cut-and-cover would balance. So far as possible, this has been done. The elevation of the invert of the aqueduct and the flow line is, however, determined at several points by other considerations.

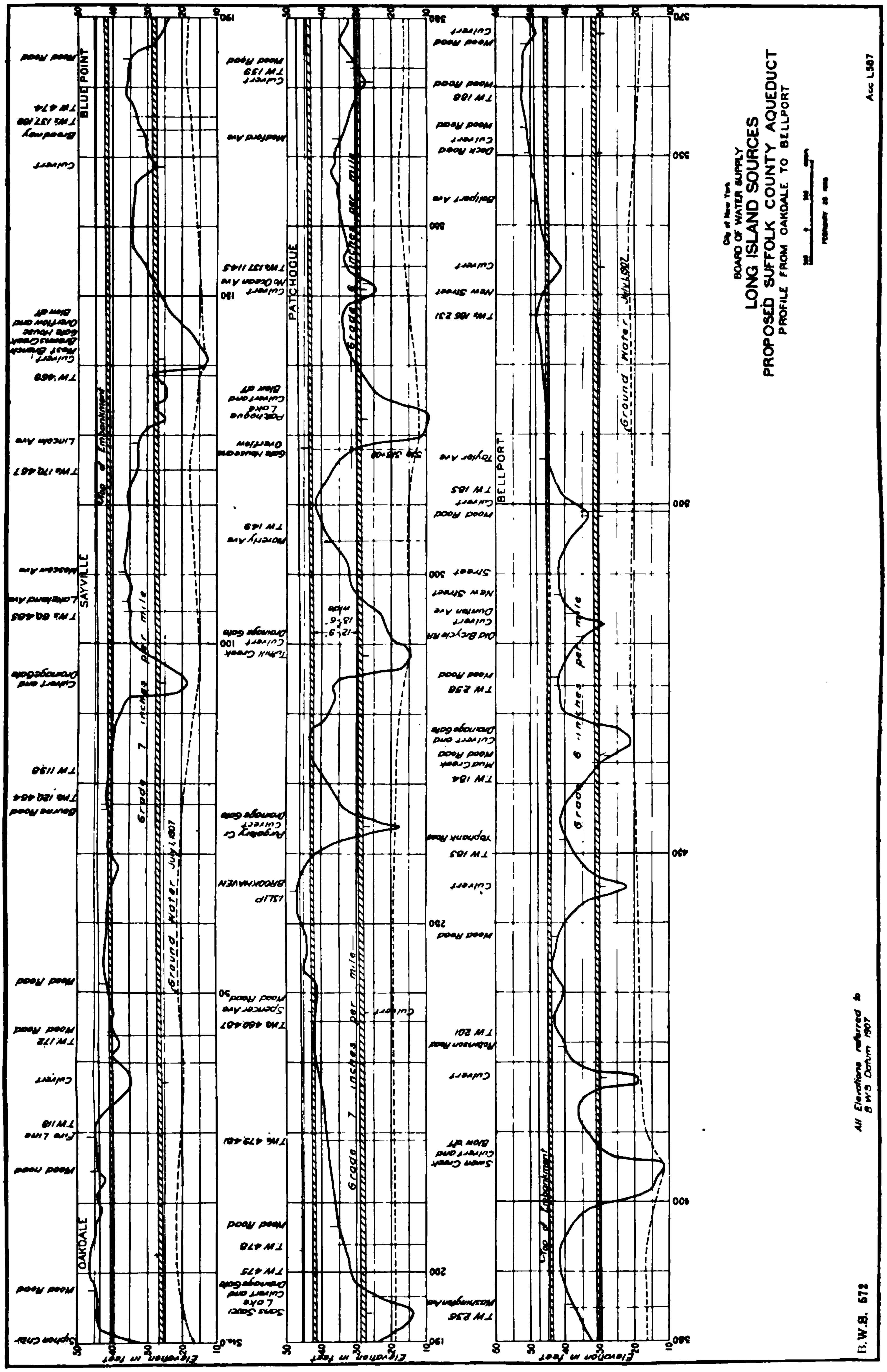

LONG ISLAND SOURCES
PROPOSED SUFFOLK COUNTY AQUEDUCT
PROFILE FROM RIDGEWOOD TO NASSAU COUNTY LINE
ALL ELEVATIONS REFERRED TO B.W.S. DATUM.
ALTERNATE FRESH CREEK LINE
RIDGEWOOD LINE
AQUEDUCT
BROOKLYN
JAMAICA SOUTH
SPRINGFIELD
ROSE DALE
B.W.S. 553

SHEET 87

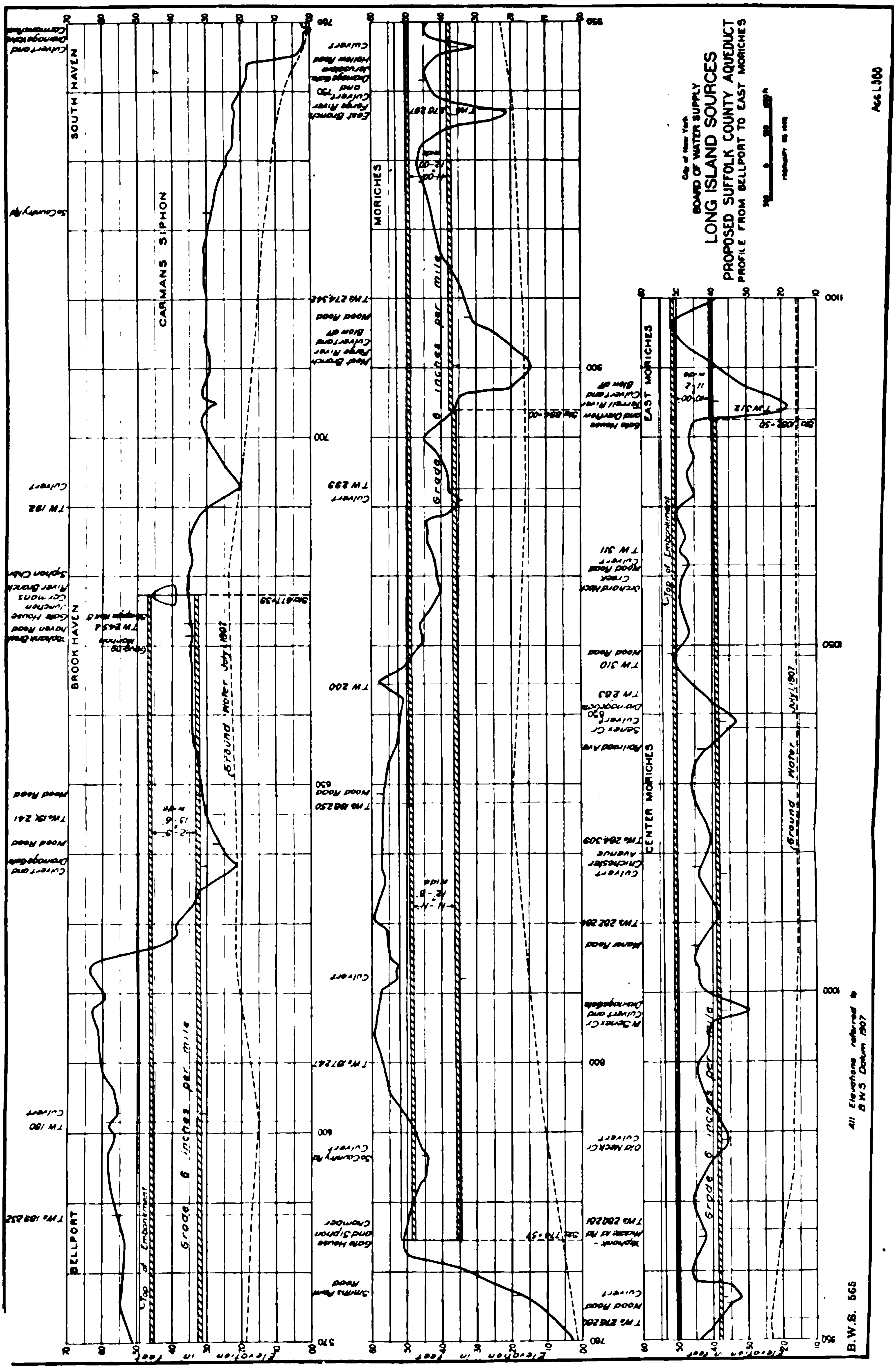

BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED SUFFOLK COUNTY AQUEDUCT
PROFILE FROM NEW YORK CITY LINE TO
SUFFOLK COUNTY LINE
LYNBROOK
VALLEY STREAM
ROSEDALE
ROCKVILLE CENTER
FREEPORT
MERRICK
MASSAPEQUA
WANTAGH
BELLMORE
Elevation in Feet
Grade 7 inches per mile
Grade 109 inches per mile
Ground Water July 1 1907
Top of Embankment
All Elevations referred to BWS Datum 1907
B.W.S. 557

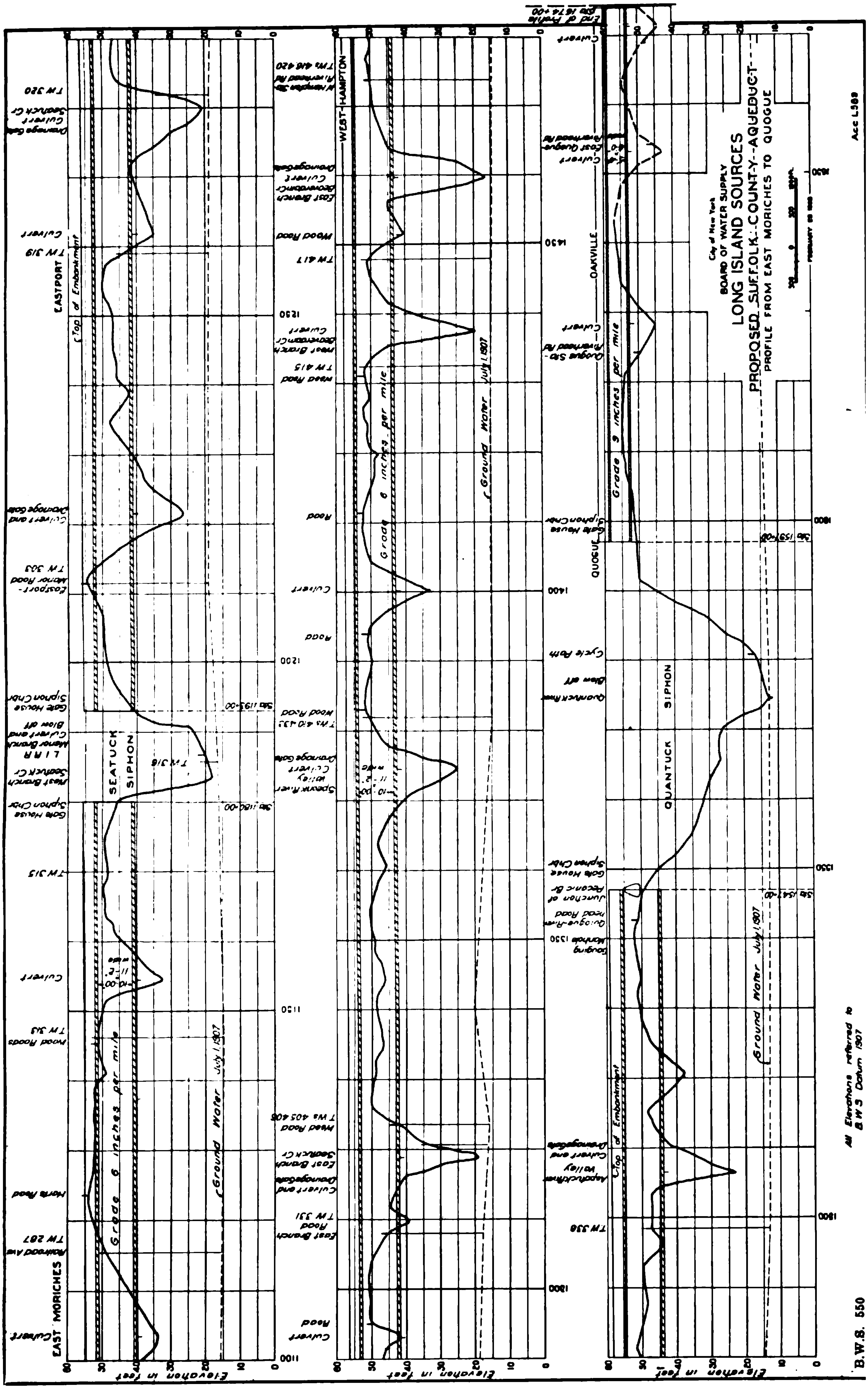

City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED SUFFOLK COUNTY AQUEDUCT
PROFILE FROM NEW YORK CITY LINE TO SUFFOLK COUNTY LINE
LYNBROOK
VALLEY STREAM
VALLEY STREAM SIPHON
ROCKVILLE CENTER
FREEPORT
MERRICK
BELLMORE
WANTAGH
MASSAPEQUA
Top of Embankment
Ground Water July 1, 1907
Grade 10 inches per mile
Grade 7 inches per mile
Elevation in feet
All Elevations referred to B.W.S. Datum 1907
B.W.S. 568


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED SUFFOLK COUNTY AQUEDUCT
PROFILE FROM NASSAU COUNTY LINE TO OAKDALE
AMITYVILLE
LINDENHURST
BABYLON
BAYSHORE
ISLIP
Station from Nassau County
Ground Water July 1, 1907
Grade 7 inches per mile
Top of Embankment
CONNETQUOT SIPHON
South Side Sportsman Club
All Elevations referred to B.W.S. Datum 1907
Elevation in feet
B.W.S. 563


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED SUFFOLK COUNTY AQUEDUCT
PROFILE FROM OAKDALE TO BELLPORT
Acc L587
All Elevations referred to B.W.S. Datum 1907
B.W.S. 572
OAKDALE
SAYVILLE
BLUE POINT
PATCHOGUE
BELLPORT
Grade 7 inches per mile
Grade 6 inches per mile
Ground Water July 1907
Elevation in feet

SHEET 91


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED SUFFOLK COUNTY AQUEDUCT
PROFILE FROM BELLPORT TO EAST MORICHES
BELLPORT
BROOK HAVEN
SOUTH HAVEN
CARMANS SIPHON
MORICHES
CENTER MORICHES
EAST MORICHES
Top of Embankment
Grade 6 inches per mile
Ground Water July 1 1907
Elevation in feet
All Elevations referred to B.W.S. Datum 1907
B.W.S. 565
Acc L 300


City of New York
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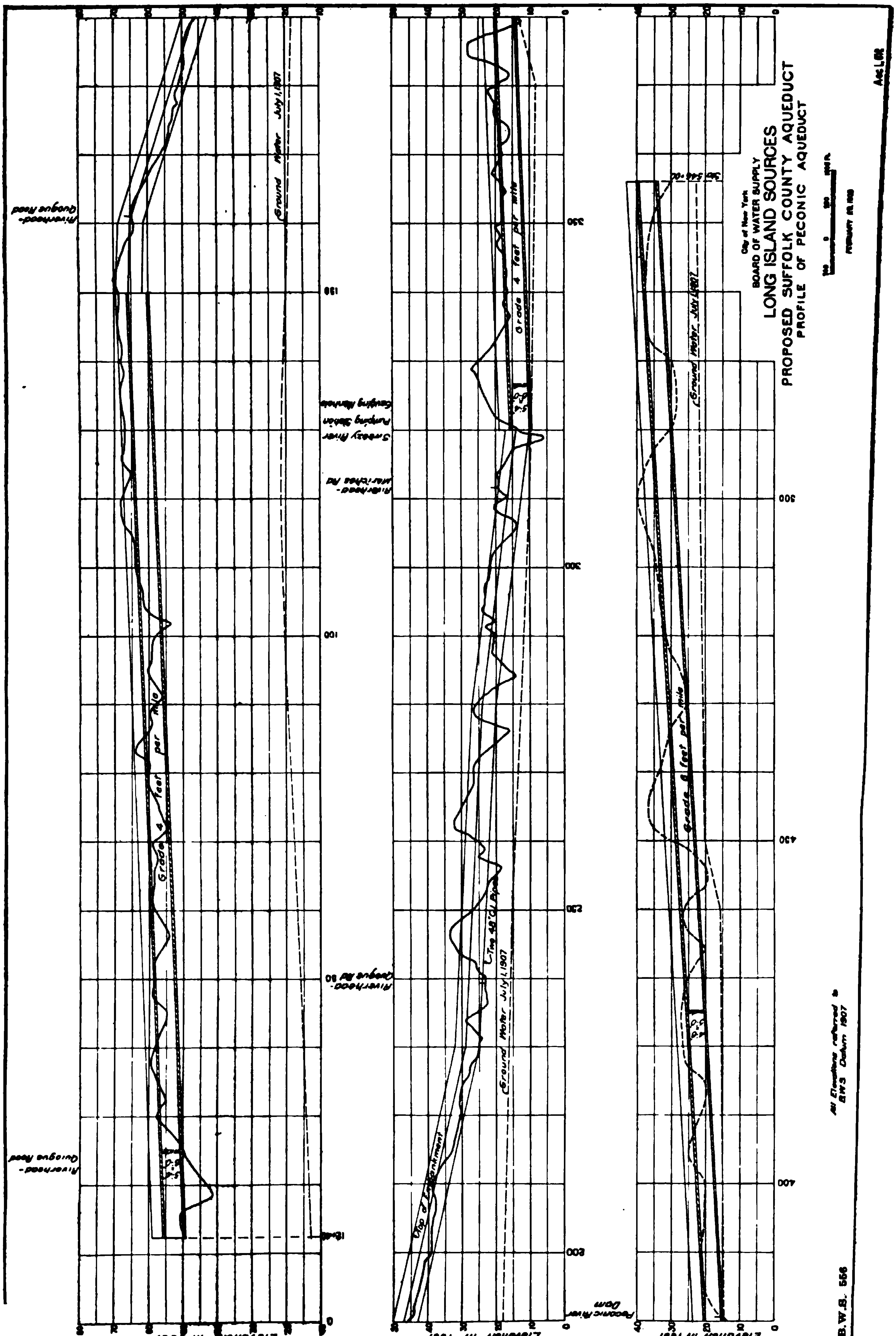
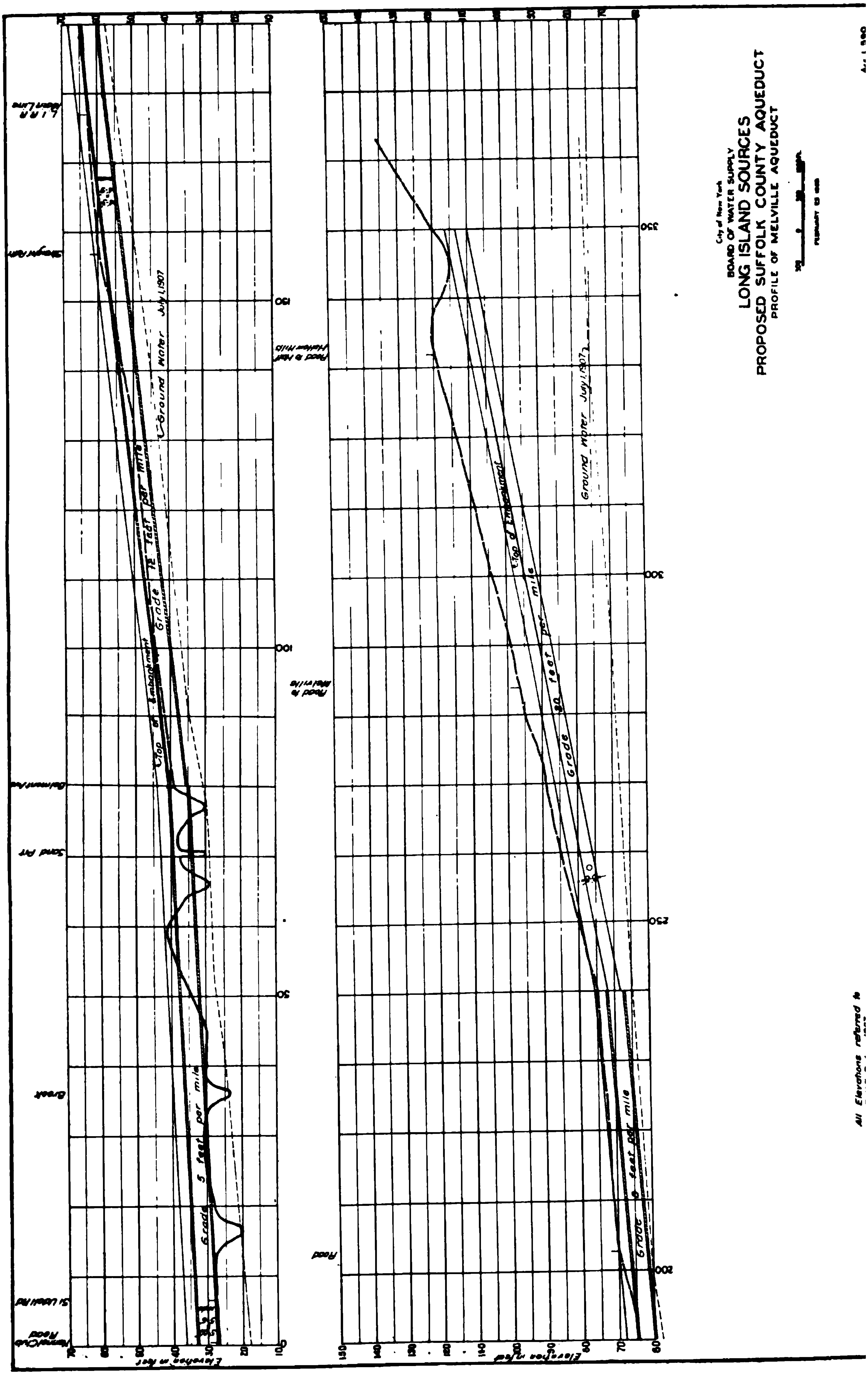
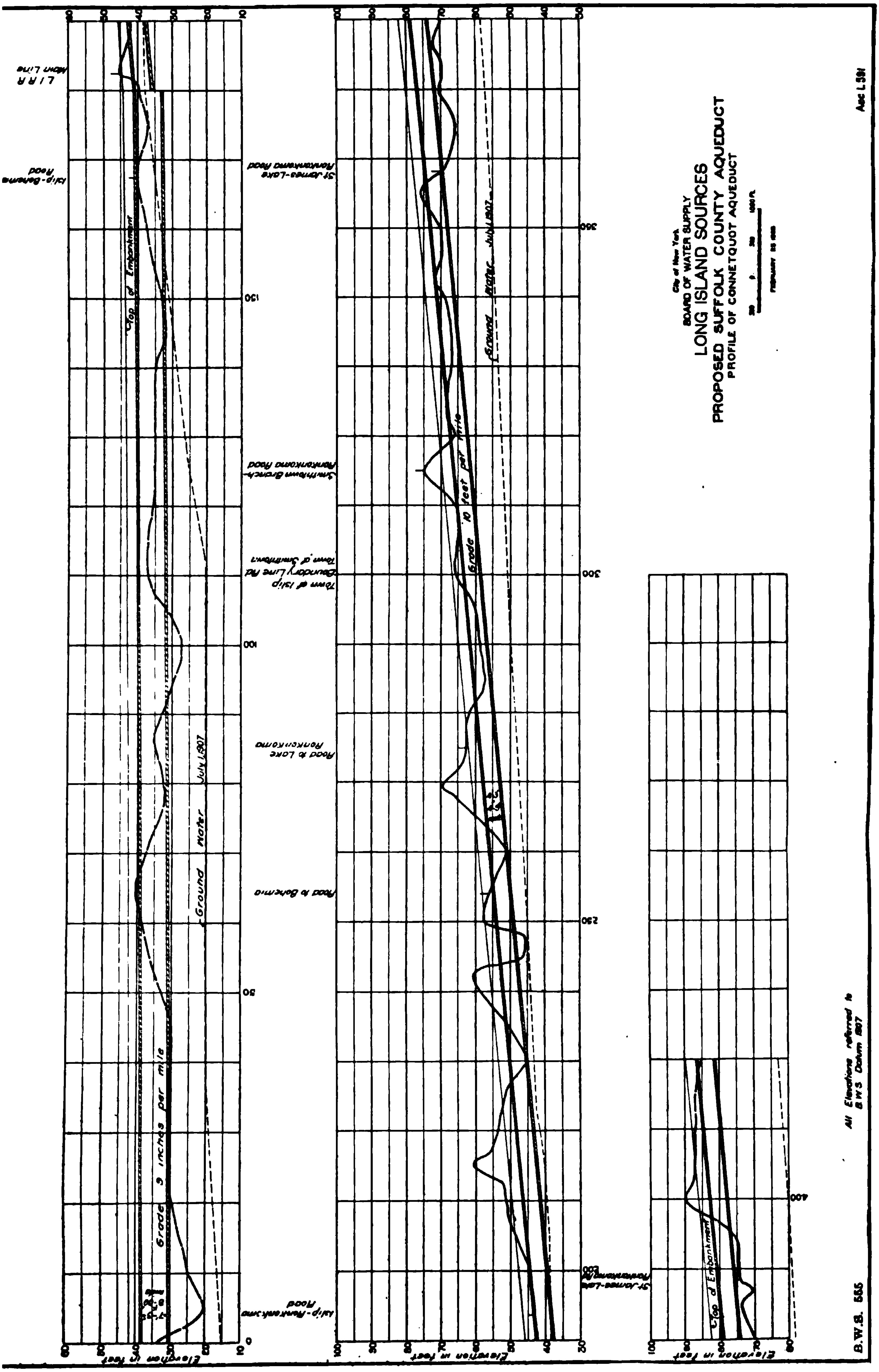
LONG ISLAND SOURCES
PROPOSED SUFFOLK-COUNTY-AQUEDUCT
PROFILE FROM EAST MORICHES TO QUOGUE
Acc L389
All Elevations referred to B.W.S. Datum 1907
Elevation in feet
EAST MORICHES
EASTPORT
SEATUCK SIPHON
WEST-HAMPTON
OAKVILLE
QUOGUE
QUANTUCK SIPHON
Grade 6 inches per mile
Grade 9 inches per mile
Ground Water July 1,1907
Top of Embankment
End of Profile Sta 1674+00

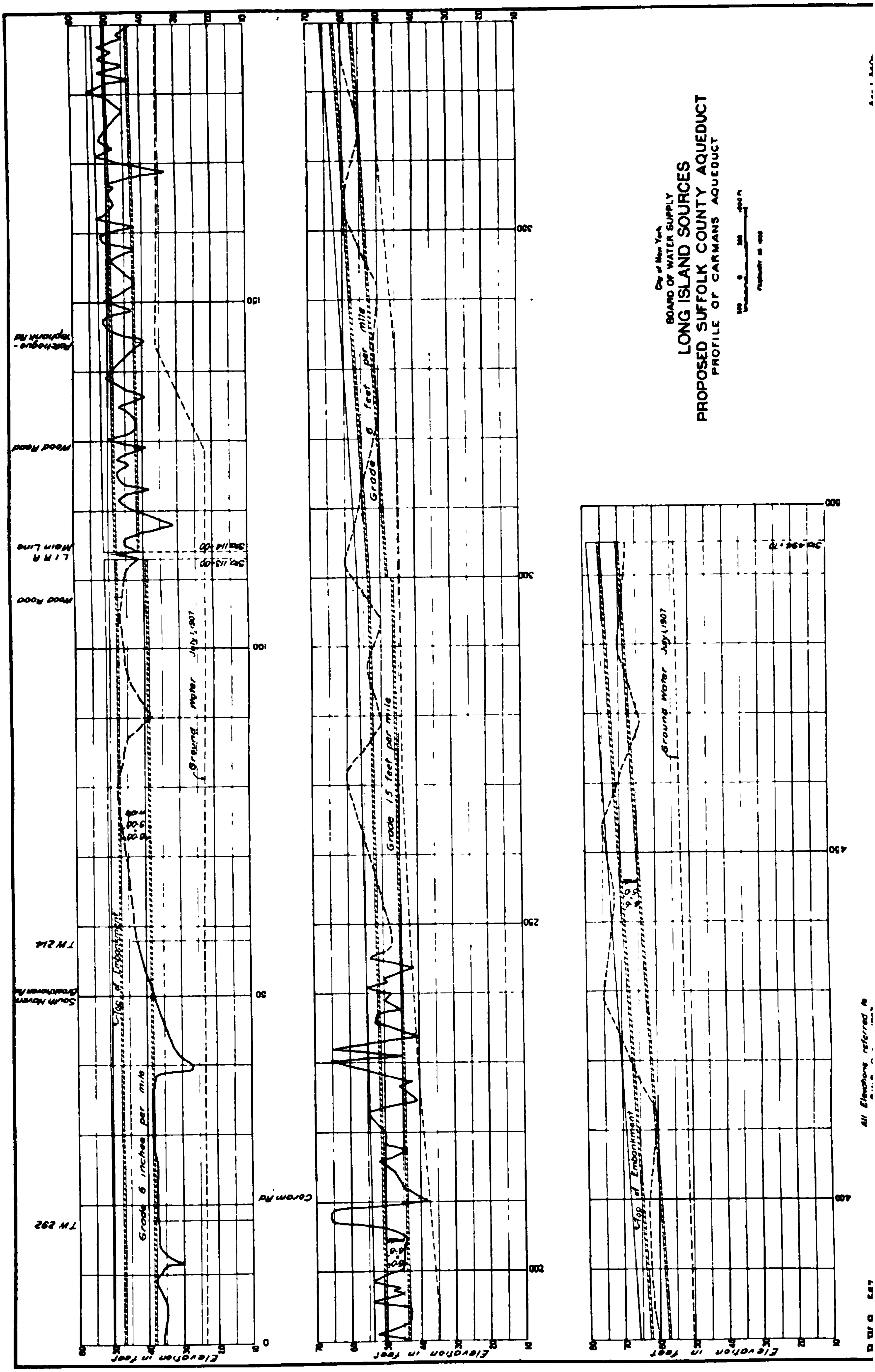
B.W.S. 550

SHEET 93


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED SUFFOLK COUNTY AQUEDUCT
PROFILE OF PECONIC AQUEDUCT
All Elevations referred to B.W.S. Datum 1907
B.W.S. 556
Ground Water July 1, 1907
Grade 4 feet per mile
Elevation in feet
Riverhead-Quogue Road
Sweezy River Pumping Station Gauging Manhole
Riverhead-Moriches Rd
Riverhead-Quogue Rd 80
Peconic River Dam
Top of Embankment


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED SUFFOLK COUNTY AQUEDUCT
PROFILE OF MELVILLE AQUEDUCT
Top of Embankment
Grade 12 feet per mile
Ground Water July 1, 1907
Grade 5 feet per mile
Grade 20 feet per mile
Grade 6 feet per mile
Elevation in feet
Road to Melville
Sand Pit
Brook
Road
All Elevations referred to


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED SUFFOLK COUNTY AQUEDUCT
PROFILE OF CONNETQUOT AQUEDUCT
Acc L 591
All Elevations referred to B.W.S. Datum 1907
B.W.S. 585
Top of Embankment
Grade 9 inches per mile
Ground Water July 1907
Grade 10 feet per mile
Elevation in feet
L.I.R.R. Main Line
Islip-Bohemia Road
St James-Lake Ronkonkoma Road
Smithtown Branch-Ronkonkoma Road
Town of Islip Boundary Line Rd Town of Smithtown
Road to Lake Ronkonkoma
Road to Bohemia
Islip-Ronkonkoma Road


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED SUFFOLK COUNTY AQUEDUCT
PROFILE OF CARMANS AQUEDUCT
Elevation in feet
Ground Water July 1, 1907
Grade 6 inches per mile
Grade 6 feet per mile
Grade 1.5 feet per mile
Top of Embankment
Patchogue-Yaphank Rd
Mead Road
L.I.R.R. Main Line
Sta. 114+00
Sta. 113+00
T.W. 214
South Haven Brookhaven Rd
T.W. 292
Coram Rd
Sta. 496+70
All Elevations referred to

Grade of Aqueduct in Suffolk County

The elevation and grade of the aqueduct in Suffolk county is fixed within somewhat narrow limits by the elevation of the ground-water in the first 15 or 20 miles. The aqueduct should be as near the ground-water surface as possible on the line of the collecting works, in order to minimize the lift of the pumps, and yet not so deep in the saturated sands as to increase the cost of the aqueduct beyond the possible saving in operating expenses. The elevation of the invert of the aqueduct of Elevation 16, at the Nassau-Suffolk County line that has been fixed, and a grade of seven inches per mile as far east as Patchogue, does not depress the aqueduct very far below the water-table. The grade of the smaller sections of the main aqueduct from Patchogue to the junction of the Peconic aqueduct at Westhampton, is reduced from seven inches to six inches per mile, in order to fit the ground without moving the line farther inland than required by the collecting works. The ground-water in eastern Suffolk county is low and the ground surface high, so that the lift into the aqueduct increases towards the easterly end of the works. There appears to be no way to avoid this with a continuous gravity aqueduct without moving the easterly portion of the line farther back from the south shore and placing the aqueduct in very deep excavation.

Suppose for the moment that it would be safe to move the line in eastern Suffolk county beyond the Carman's river, nearer the south shore without greater danger of the entrance of sea-water, and place the gravity aqueduct at a lower elevation, and somewhat nearer the ground-water surface. A saving in the lift of the ground-water into the aqueduct of possibly 10 feet might thus be effected, but this plan would require another pumping-station at the Carman's river to lift into the main gravity aqueduct running to Brooklyn the entire supply gathered east of this point, including the yield of the Peconic Valley works.

The cost of pumping the wells at the third stage of construction, exclusive of fixed charges, is estimated at 14 cents per million foot-gallons, and there would be 70 million gallons per day, or 25,550 million gallons per year to be pumped.

The pumping station at Carman's river would have to lift this volume of 70 million gallons per day, and in addition, the 30 million gallons from the Peconic valley, and it would

not be safe to estimate for this low lift plant on less than 4 cents per million foot-gallons.

The annual saving of 10 feet in lift on 70 million gallons daily would amount to 25,550 x 10 x 0.14=$35,770, but against this, 100 x 365=36,500 million gallons daily would be pumped daily an equal distance at a cost each year of 36,500 x 10 x 0.04=$14,600. The net annual saving would be $21,170, which capitalized at five per cent., would amount to $423,400.

The saving effected by placing the easterly end of the main aqueduct at a lower elevation to minimize the lift in the wells, would hardly pay the fixed charges on the cost of the necessary pumping-station at the Carman's river. Such a location is not desirable anyway because it would be too near the sea.

In order to secure the full yield of the Peconic Valley watershed, the collecting works would be located at the downstream end of the valley. The water, collected in the gravity aqueduct and delivered to the proposed pumping-station near Sweezy pond at Riverhead, must be pumped over the hill separating the Peconic valley from the southerly slope of the island. The force mains would not, however, be long, nor necessarily large, and they would deliver the supply at the summit of the hill into a cut-and-cover aqueduct, which would convey the water by gravity to the main south shore aqueduct at Westhampton.

The branch lines would be constructed at reasonable depths for cut-and-cover sections, and because of the natural slope of the island, small and inexpensive aqueducts could be built.

Grade of Aqueduct in Nassau and Queens Counties

At the westerly end of the line near the Ridgewood pumping-station, it seems essential that the flow line of the new aqueduct should be at such an elevation that, if desired, the entire flow of the old brick conduit of the Ridgewood system could be taken into the new aqueduct, or a portion of the new Suffolk County supply could be delivered through the old structure to the present Ridgewood pumping-station. To effect this, a cross connection is proposed at Spring creek, where the flow line of the new aqueduct would be placed at Elevation 10 above the B. W. S. datum. This elevation of the flow line would depress the aqueduct below the groundwater in the westerly portion of the line, but this grade is

not lower than is necessary through much of Queens county, to secure material for embankment without borrowing from expensive lands now devoted to truck farming or being developed for suburban residences.

Beginning with invert elevation of 16.0, at the Nassau-Suffolk County line, a grade of seven inches per mile to Smiths pond could be maintained with little deep excavation, except north of Freeport and Rockville Center, and with few embankments of sufficient hight to damage the lands through which the aqueduct would pass. From Smiths pond to Ridgewood, a grade of over 10 inches per mile could be secured to the point of control at Spring creek, and a large capacity secured to take the flow of Hempstead storage reservoir and the other Brooklyn works, as already explained.

Alternative Location of Aqueduct in Nassau County

The location here proposed between Rosedale and Millburn reservoir, north of the villages of Valley Stream, Lynbrook, and Rockville Center, which is shown on the general map, Sheet 4, Acc. 5602, page 26, as a full red line, would do much less damage and would cause less annoyance than a line farther south, although, at several points on the northerly line, the aqueduct would be in deep excavation and at some depth below the surface of the ground-water. This line is proposed because it is thought better to keep away from the villages and thus avoid any disturbance there.

The alternative line through the villages of Valley Stream, Lynbrook and Rockville Center, shown on the general map as a dotted red line, would be somewhat cheaper than the northerly line, even with the greater cost of land on the southerly route, and the expense of a siphon at Valley Stream. Should the Department of Water Supply acquire the wide right-of-way over this alternative southerly location, the Suffolk County aqueduct should of course be built on this line.

The relative cost of the aqueduct on these two locations is shown below:

Item	Northerly Location Proposed	Southerly Alternative Location
Land and damages	$317,650	$336,400
Earth work	514,300	428,650
Pumping ground-water	293,000	203,300
Masonry aqueduct	980,000	1,025,650
Special structures and improvements	240,250	268,570
Total, exclusive of engineering and contingencies	**$2,345,200**	**$2,262,570**

COST OF AQUEDUCT CONSTRUCTION

On each of the diagrams showing the details of the Suffolk County Aqueduct sections, Sheets 98 to 102, inclusive, Accs. LJ 133, L 594, L 606, L 331 and L 593, curves of earth work and masonry quantities are drawn for any depth of cut or fill. From these curves the cost of each section of aqueduct in dry earth excavation has been worked up, and is shown in the upper right hand corner. This cost curve does not include land and water damages, right-of-way, special structures or supervision. Each curve is based on the following unit prices:

Excavation dry, slope 1 to 1, including soil stripping	$0.35 per cubic yard
Embankment and refill	.30 per cubic yard
Soil dressing, re-excavation and placing	.40 per cubic yard
Concrete masonry, including cement and forms	7.50 per cubic yard
Lumber	50.00 per M feet B. M.

The earth quantities, regarding which the greatest uncertainty must exist in the preliminary estimates, are purposely given fairly high unit prices in these estimates. Most of the earth work in dry trench could be done by steam-shovel, trench machine, scraper, or other labor saving machinery, and the prices, including a reasonable profit, should be less than here given. No allowance is made for borrow in the estimate of embankment and refill, but a price of 15 cents to 25 cents has been made for spoil in proportion to the length of overhaul. In most localities it should be possible to secure the necessary depth of soil from the surface of the excavation.

It should be possible to place the concrete masonry in the aqueduct, with present prices of cement, for $7.50 per cubic yard, although there is less margin of safety in this than in the earth quantities, because it has been possible to compute the masonry yardage more closely. Sand is everywhere abundant, and gravel would be found occasionally in the trench.

Liberal estimates on the cost of handling the water by means of temporary driven wells, show that the cost would be about $5.60 per foot of aqueduct when the ground-water level is 2 feet or less above the subgrade. This cost would increase about 40 cents per foot for each additional foot of groundwater in the trench, because of additional pumpage required

to keep the ground-water at a lower depth. The cost of $6 per foot in three feet of water where the excavation, for example, amounts to 20 to 30 cubic yards per linear foot, would add 20 or 30 cents per yard to the excavation, but this method would be cheaper than the less desirable plan of handling the water in the trench, which is estimated, with platforms and central drains, to cost $9 per foot, with the same depth of water above subgrade.

CONNECTIONS WITH RIDGEWOOD SYSTEM

The cross connection between the proposed aqueduct and the old brick conduit at Spring creek is estimated as an 8-foot aqueduct with a nominal capacity of 100 million gallons per day. The proposed branch aqueduct from Hempstead storage reservoir to the Suffolk County aqueduct is also planned as an 8-foot conduit, and the capacity is also estimated at 100 million gallons per day.

Several special structures in addition to the connection mentioned above are included in the estimate of this branch aqueduct, a gate-house and connection with existing works at the reservoir, a culvert at Smiths pond, blow-off, gaging and inspection manholes and, for the southerly alternative location, a crossing of the Long Island railroad.

A connection is also estimated from the proposed branch aqueduct from Hempstead storage reservoir to the old brick conduit. Another connection to the proposed Suffolk County aqueduct is proposed from the Millburn pumping-station. This is estimated as a reinforced section, seven feet in diameter, and is designed to carry 70 million gallons per day, somewhat more than the full delivery of the "new conduit." Estimates include necessary changes in piping at Millburn pumping-station, and a right-of-way for the connection. A similar connection of the same capacity is estimated between the main aqueduct and the new pumping-station proposed by the Department of Water Supply at Massapequa. This would be built on a grade to deliver by gravity the first installment of the Suffolk County ground-waters to Massapequa and to the City through the proposed Massapequa pumping-station and the proposed extension of the 72-inch pipe-line.

SPECIAL STRUCTURES

The complete topographical surveys of the proposed right-of-way have permitted the special structures to be studied in

greater detail than is ordinarily possible for preliminary estimates on a project of this kind.

Gate-house and Appurtenances

Gate-houses have been planned at cross connections between the Suffolk County aqueduct and the Ridgewood conduits, at junctions with aqueducts and conduits from reservoirs and pumping-stations of the Ridgewood system, at junctions of the proposed branch aqueducts in Suffolk county, and at other points where overflows and siphon chambers are suggested. These gate-houses are tabulated below with appurtenances provided at each:

Station from Ridgewood	Location	Near	Appurtenances
	NASSAU COUNTY		
482 +40	Beginning Valley Stream siphon	Valley Stream	Gates, siphon chamber
488 +50	Valley Stream siphon	Valley Stream	Gates, pumps, culvert and blow-off
506 +40	End Valley Stream siphon	Valley Stream	Gates, siphon chamber
631 +90	Junction Hempstead branch conduit	Rockville Center	Gates, blow-off, overflow, connection for Hempstead branch conduit
954 +00	East Newbridge stream	Merrick	Gates, culvert, drainage valve, overflow
1,186 +00	Massapequa stream	Massapequa	Gates, culvert, overflow, drainage valve, connection from pumping-station
	SUFFOLK COUNTY		
1,572 +71	Junction Melville aqueduct	Babylon	Gates, overflow
2,068 +21	Junction Connetquot aqueduct	Great River	Gates, siphon chamber, overflow
2,174 +75	End Connetquot siphon	Great River	Gates, siphon chamber
2,320 +00	West branch, Browns creek	Sayville	Gates, culvert, overflow, blow-off
2,492 +75	Patchogue lake	Patchogue	Gates, overflow
2,852 +14	Junction Carman's aqueduct	Brookhaven	Gates, siphon chamber
2,949 +32	End Carman's siphon	Brookhaven	Gates, siphon chamber
3,255 +25	Terrell river	East Moriches	Gates, overflow, culvert, blow-off
3,354 +75	Beginning Seatuck siphon	East Moriches	Gates, siphon chamber
3,367 +75	End Seatuck siphon	East Moriches	Gates, siphon chamber
3,721 +75	Junction Peconic aqueduct	Quogue	Gates, siphon chamber
3,771 +75	End Quantuck siphon	Quogue	Gates, siphon chamber

The cost of a gate-house is estimated for those below: Nassau County line and Oakdale, at $9,000 each; 10-inch drainage gates, $75; manholes, $75; 24-inch blow-off, $300

In the type of gate-house adopted for estimates of cost the overflows are designed to discharge a large volume of water when the stop-planks are removed and the gate-houses are placed sufficiently near together to relieve the aqueduct of undue pressure in the event of interruptions to the flow. Grooves for stop-planks would be provided for the purpose of cutting off sections for cleaning and repairs.

Culverts

The type of culvert adopted in the preliminary estimates of cost is shown on Sheet 103, Acc. L 668. The sizes of the culverts are estimated liberally to take care of infrequent floods on the Long Island watersheds, occasioned by warm rains on snow covered, frozen ground. The sizes have been based upon observations of a freshet on February 26, 1902, by the Department of Water Supply, which indicated that for small watersheds of less than seven square miles, a run-off of three inches in 24 hours may be expected, and that the discharge of the larger watersheds was proportionately less. A watershed of 30 square miles yielded about one inch in 24 hours. The culverts have been computed on the assumption that a backing up of four feet on the up-stream side was permissible, except where such would endanger the safety of the existing aqueducts and pipe-lines which at some points have insufficient culvert capacity. Allowance has been made for an entry head equal to 50 per cent. of the velocity head through the culvert. The selection of the proper culvert sizes for any given watershed area has been facilitated by the construction of the diagram on Sheet 104, Acc. LJ 135. The location of the overflows, gate-houses, blow-offs and drainage gates, are shown on the profiles of the aqueduct, Sheets 86 to 96, inclusive. Blow-offs have been placed at frequent intervals, because it would be necessary to empty the aqueduct rapidly for cleaning or repairs in consequence of the small amount of storage that is provided in the distributing reservoirs of Brooklyn borough.

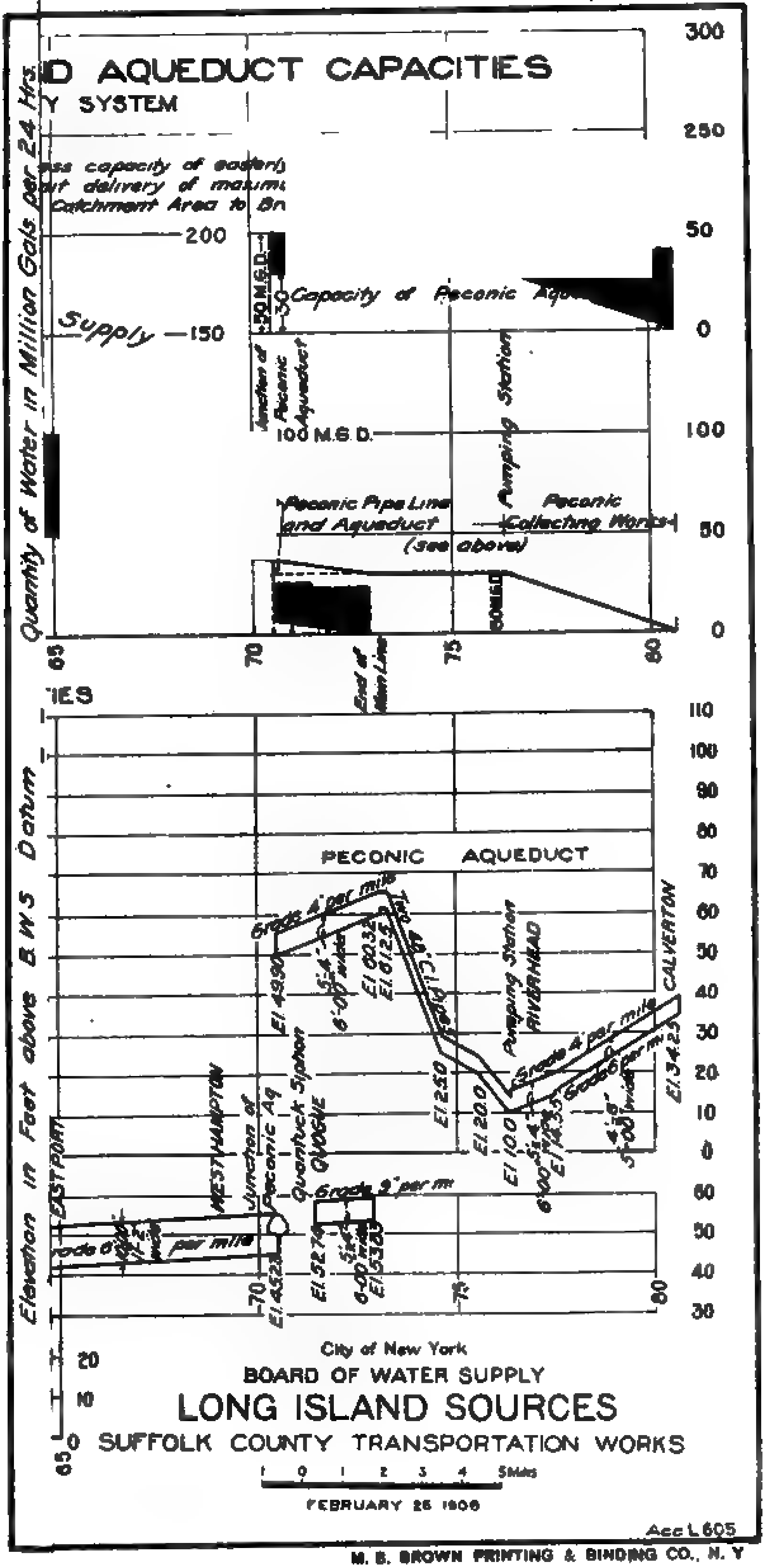
Manholes

Special manholes and blow-offs have been estimated in accordance with the standard design for the Catskill aqueduct, with 24-inch gates and drainage pipes.

Gaging manholes of the standard Catskill pattern are proposed on the main aqueduct at Lynbrook, Freeport, Amityville, Babylon, Oakdale, South Haven and Westhampton; on the cross connections to the old conduit at Spring creek; on the branches to Hempstead storage reservoir, Millburn pumping-station, and to Massapequa station; and on the branch aqueducts in Suffolk county near their junction with the main line.

Inspection manholes would be provided on the aqueducts in Nassau and Queens counties at intervals of 1/4 mile, and throughout the entire works, at the ends of siphons where

SHEET 97



M. B. BROWN PRINTING & BINDING CO., N. Y.

gate-houses and siphon chambers are not planned. The manholes of the aqueducts in Suffolk county would be placed as far as possible opposite the wells to admit of inspection and repairs to connections.

Railroad Crossings

The main aqueduct crosses the Long Island railroad at several points; the Rockaway branch near Aqueduct; the old Rockaway line between Springfield and Rosedale; the two single track branches at Valley Stream; the Long Beach branch at Lynbrook; the Montauk division (double track) at Rosedale; the Hempstead branch between Lindenhurst and Babylon, and the branch from Eastport to Manor at Eastport.

It has been assumed that the Long Island railroad would take care of its tracks at The City's expense. An estimate of $1500 for each crossing has been allowed, and an additional thickness of 12 inches of concrete is proposed to carry the train loads.

No allowance has been made for crossing street railways within the City limits, since it is assumed they are in the public highways and must look out for themselves; elsewhere $1500 has been allowed for each.

AQUEDUCT RIGHT-OF-WAY

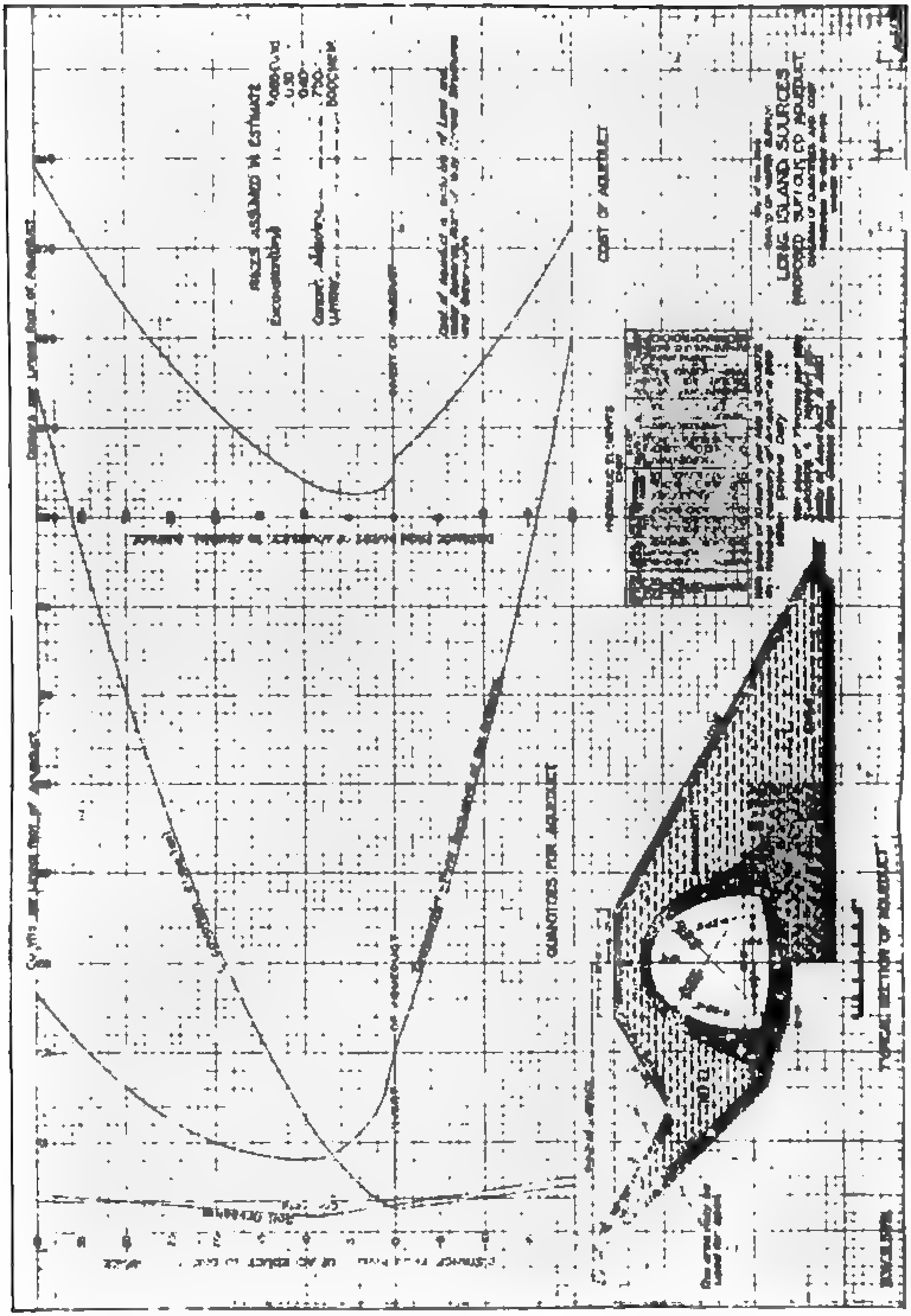
Width of Taking

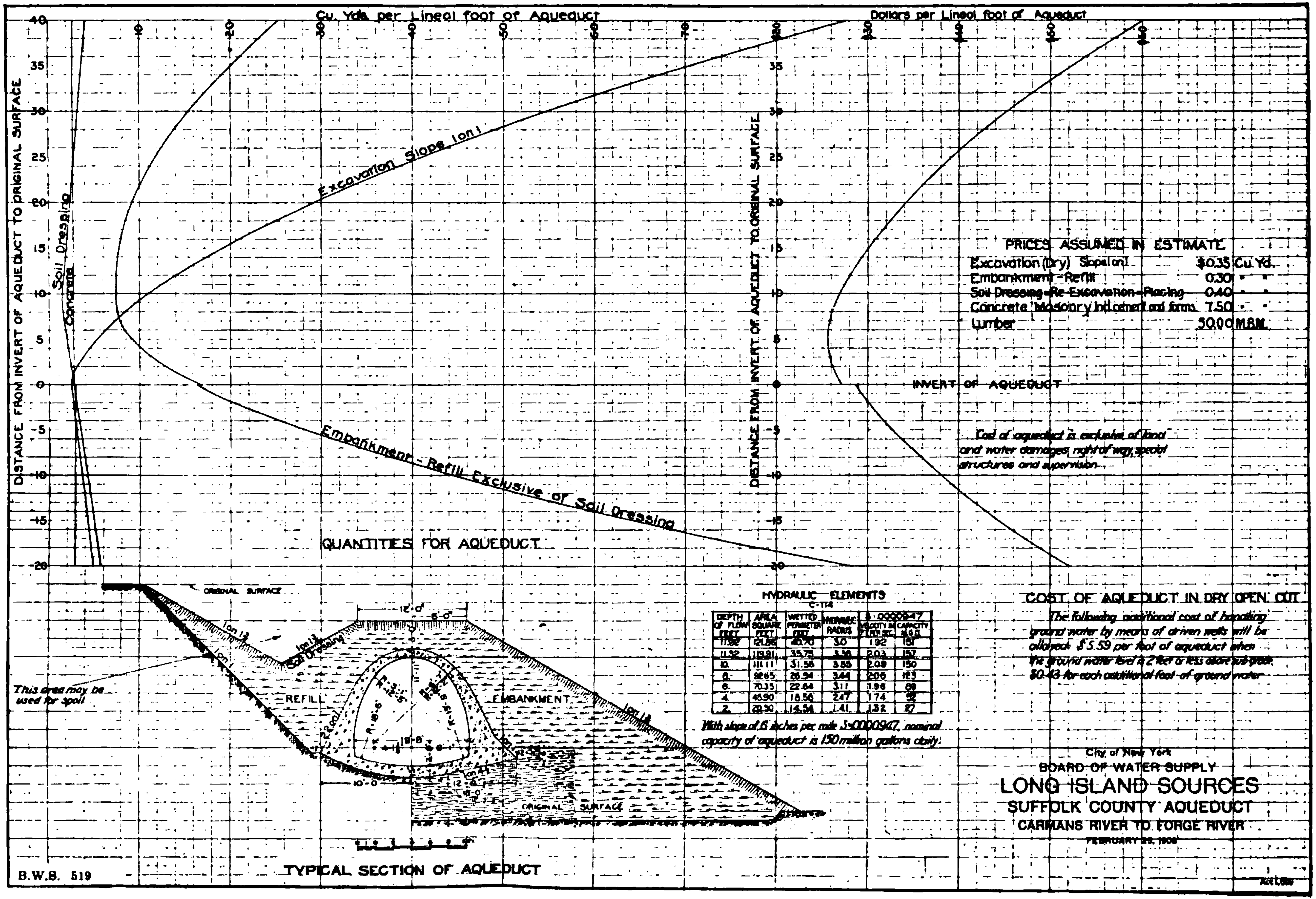
The land for the aqueducts in Suffolk county would be provided by the proposed takings for the collecting works. In Nassau and Queens, where the land is not already owned by The City, it is proposed to purchase a right-of-way 100 to 150 feet in width. Enough land has been estimated to cover what may be necessary for borrow-pits or spoil-banks, or for other construction purposes. The price estimated for these lands has been estimated upon the basis of the cost of land purchased by The City in the same locality, including the cost of necessary legal proceedings and surveys.

Improvement of Right-of-way in Nassau County

It is proposed to seed all aqueduct embankments and maintain a sod to protect the slopes. The right-of-way from Suffolk county to Ridgewood pumping-station would be fenced and improved as proposed in Suffolk county. Parks would be maintained on the right-of-way within the villages of Millburn, Freeport, Merrick, Bellmore, Wantagh and Massapequa.

SHEET 98

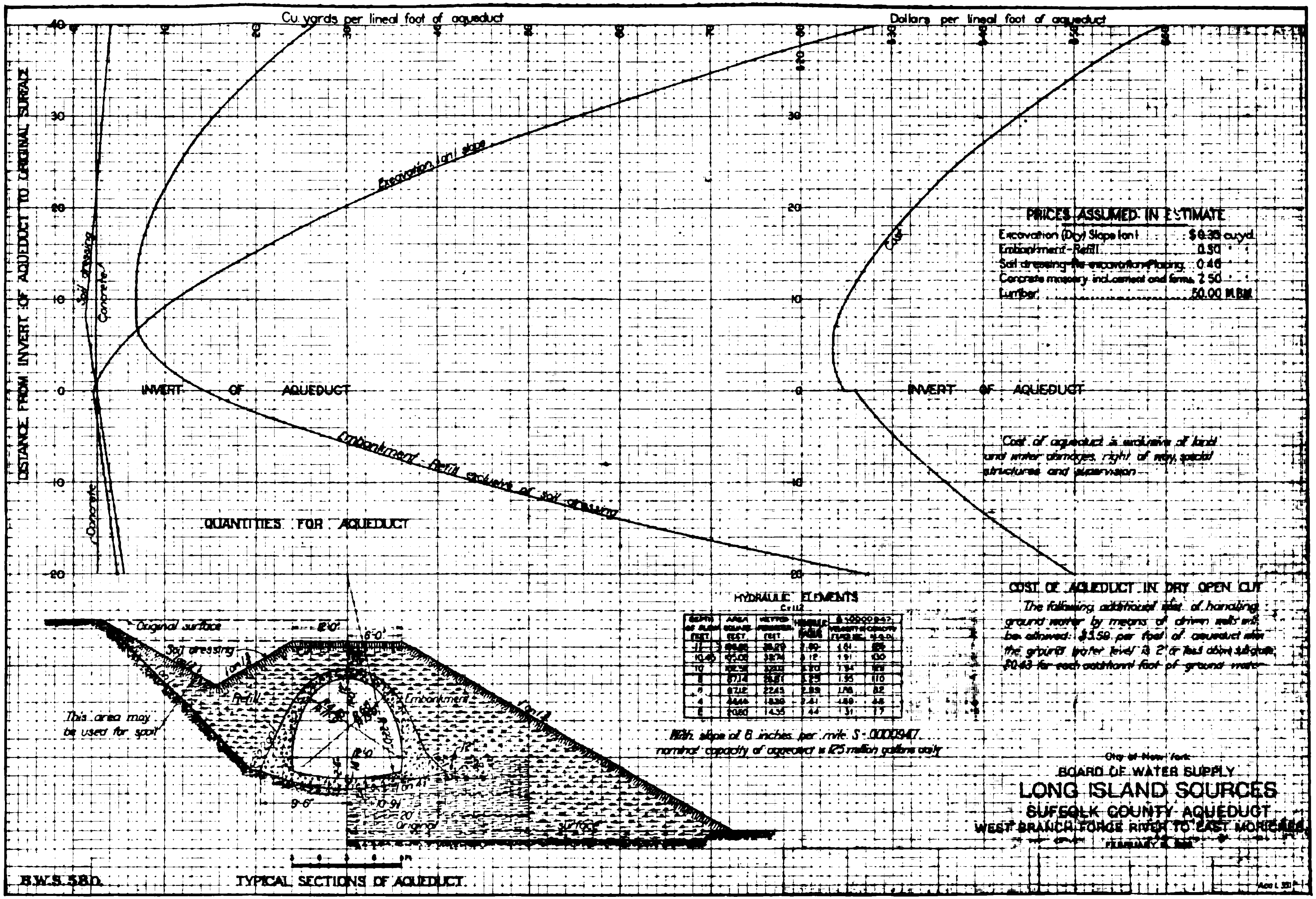

PRICES ASSUMED IN ESTIMATE
COST OF AQUEDUCT
QUANTITIES FOR AQUEDUCT
LONG ISLAND SOURCES
PROPOSED SUFFOLK CO. AQUEDUCT
TYPICAL SECTION OF AQUEDUCT

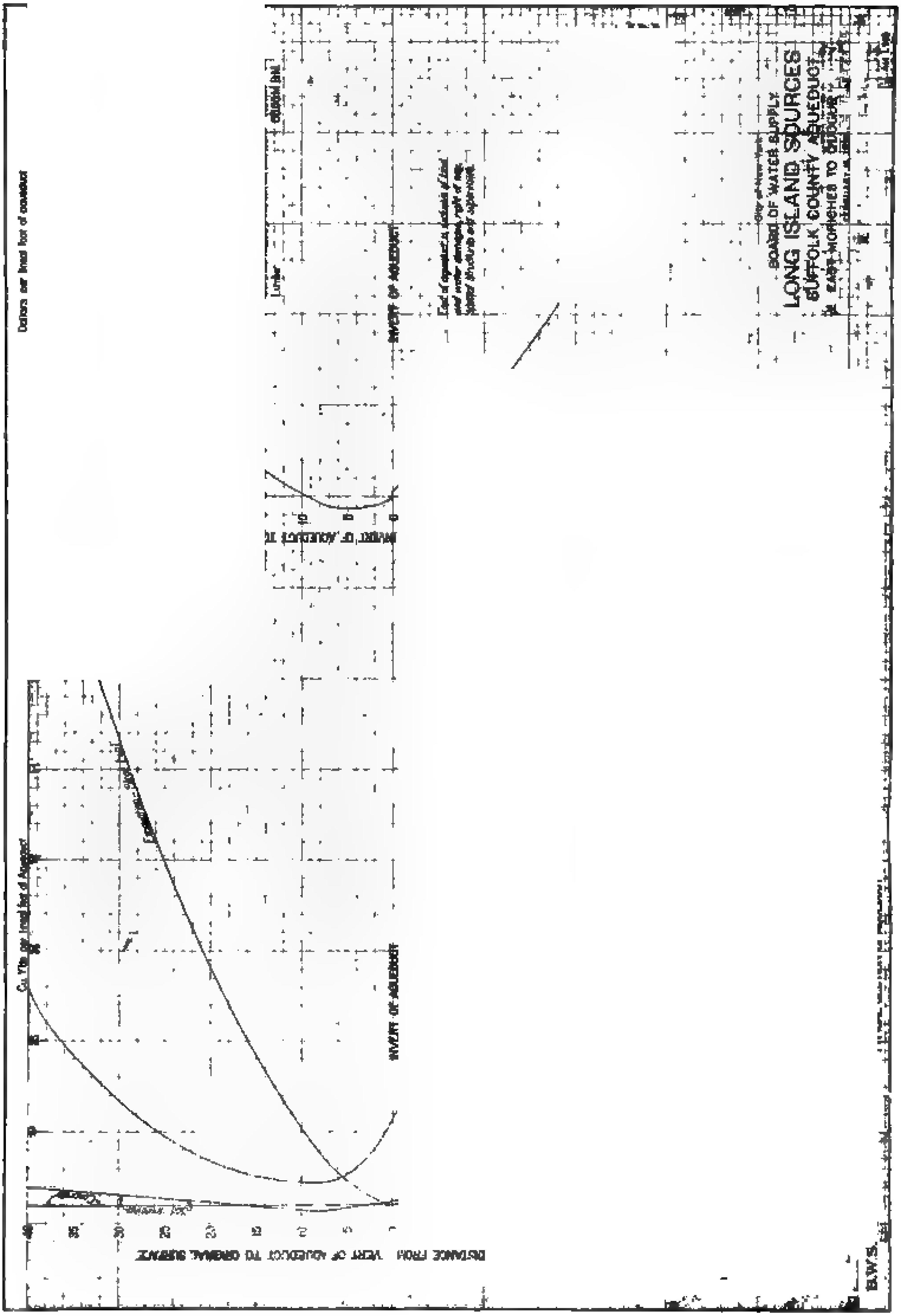


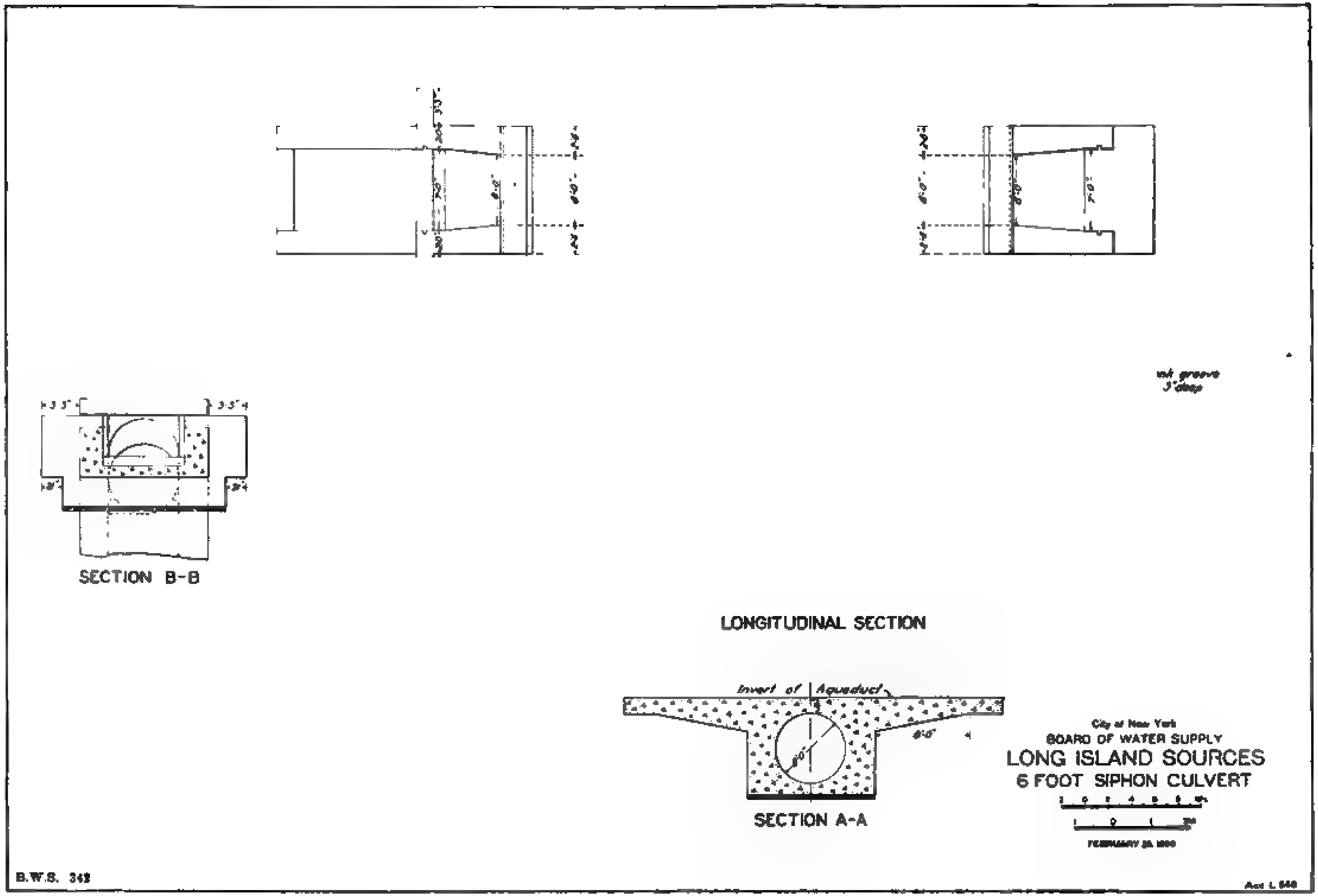
HYDRAULIC ELEMENTS
C=114

DEPTH OF FLOW FEET	AREA SQUARE FEET	WETTED PERIMETER FEET	HYDRAULIC RADIUS	S=.0000947 VELOCITY IN FT. PER SEC.	S=.0000947 CAPACITY M.G.D.
11.92	121.86	40.70	3.0	1.92	151
11.32	119.91	35.75	3.36	2.03	157
10.	111.11	31.55	3.55	2.09	150
8.	92.65	26.94	3.44	2.06	123
6.	70.35	22.64	3.11	1.96	89
4.	45.90	18.56	2.47	1.74	52
2.	20.50	14.54	1.41	1.32	27

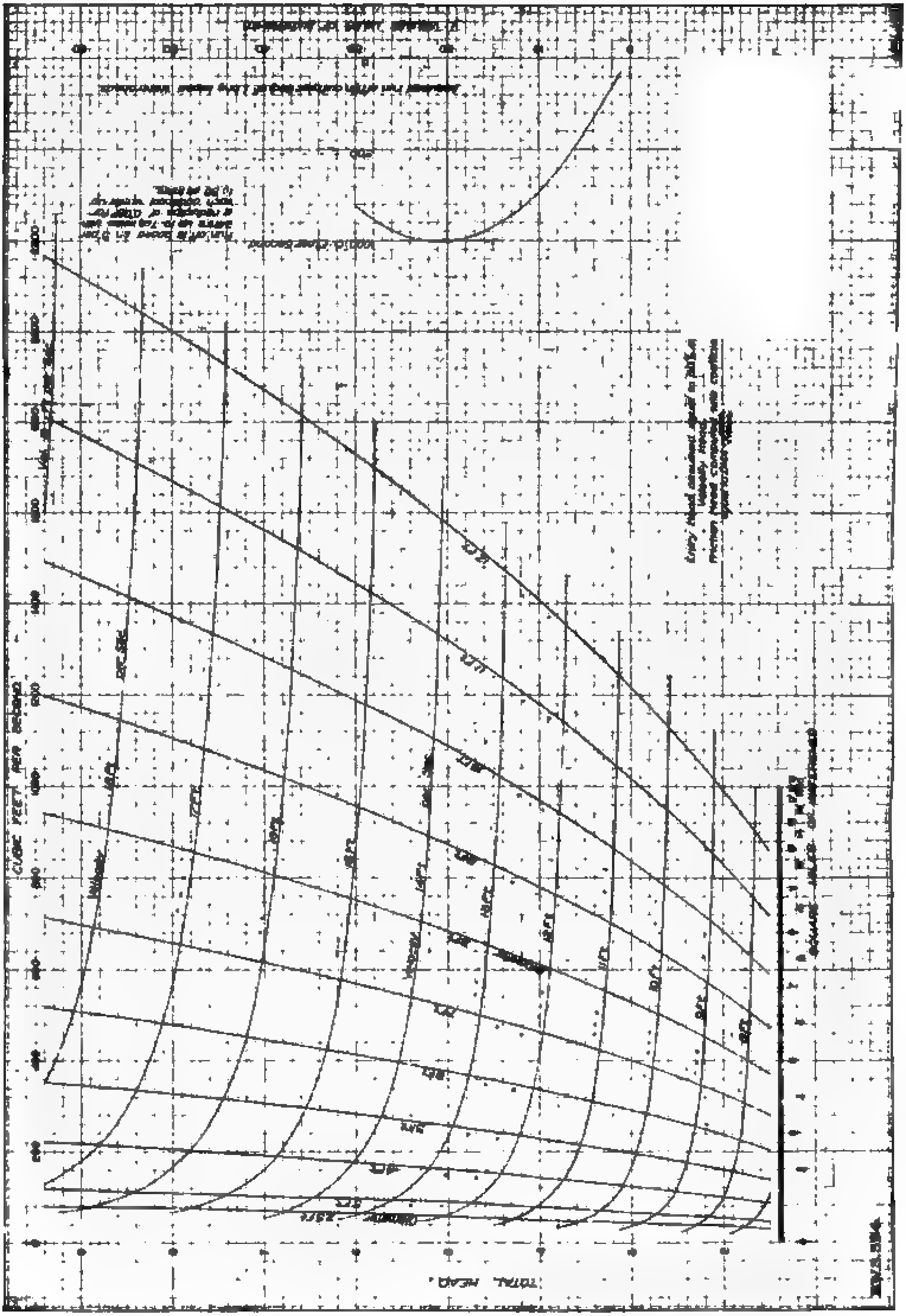
With slope of 6 inches per mile S=.0000947, nominal capacity of aqueduct is 150 million gallons daily.

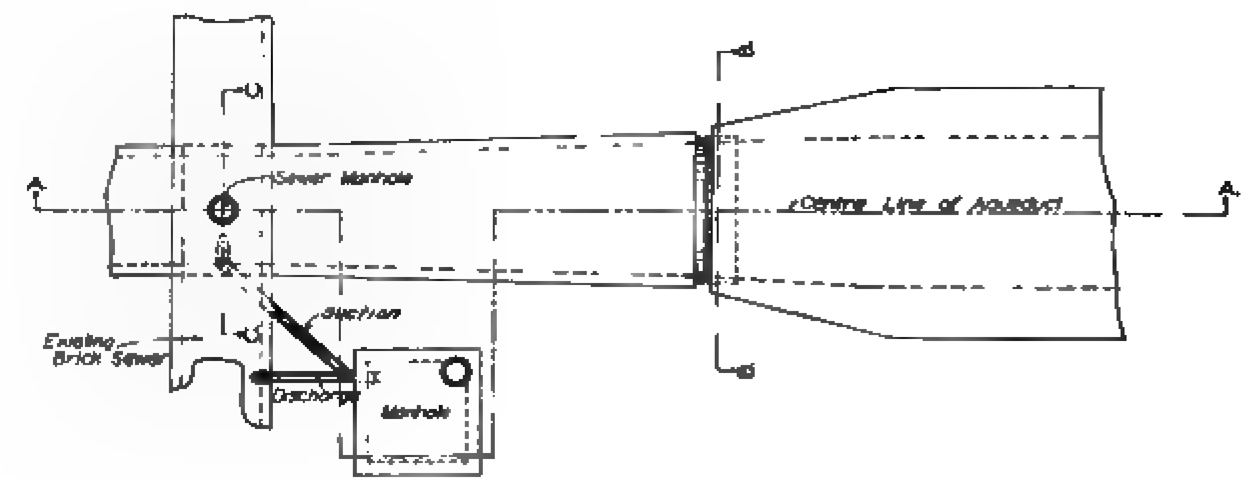

Cu. yards per lineal foot of aqueduct
Dollars per lineal foot of aqueduct
DISTANCE FROM INVERT OF AQUEDUCT TO ORIGINAL SURFACE
INVERT OF AQUEDUCT
INVERT OF AQUEDUCT
Excavation 1 on 1 slope
Embankment - Refill exclusive of soil dressing
Soil dressing
Concrete
QUANTITIES FOR AQUEDUCT
PRICES ASSUMED IN ESTIMATE
Excavation (Dry) Slope 1 on 1 . . . $0.35 cu.yd.
Embankment - Refill . . . 0.50
Concrete masonry incl. cement and forms 2.50
Lumber . . . 50.00 M.B.M.
Cost of aqueduct is exclusive of land and water damages, right of way, special structures and supervision
COST OF AQUEDUCT IN DRY OPEN CUT
HYDRAULIC ELEMENTS
C = 112
With slope of 6 inches per mile S = .0000947, nominal capacity of aqueduct is 125 million gallons daily
Original surface
Soil dressing
Refill
Embankment
This area may be used for spoil
City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
SUFFOLK COUNTY AQUEDUCT
WEST BRANCH FORGE RIVER TO EAST MORICHES
TYPICAL SECTIONS OF AQUEDUCT
B.W.S. 580.


Dollars per lineal foot of aqueduct
Cu. Yds per lineal foot of Aqueduct
DISTANCE FROM INVERT OF AQUEDUCT TO ORIGINAL SURFACE
INVERT OF AQUEDUCT
Lumber
Cost of aqueduct is exclusive of land and water damages, right of way, special structures and supervision.
City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
SUFFOLK COUNTY AQUEDUCT
EAST MORICHES TO QUOGUE
B.W.S.


SECTION B-B
LONGITUDINAL SECTION
Invert of Aqueduct
SECTION A-A
City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
6 FOOT SIPHON CULVERT
B.W.S. 342

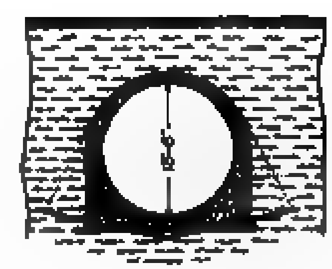
SHEET 104





PLAN OF SIPHON.

The Siphon is on Alternate Location for Aqueduct to Fresh Creek Site



SECTION C-C

SECTION A-A.

SECTION B-B.

City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED SUFFOLK COUNTY AQUEDUCT
SIPHON UNDER TRUNK SEWER
BORO. OF BROOKLYN

B.W.S. 254

PROPOSED PUMPING-STATIONS

BY ROBERT W. STEED, MECHANICAL ENGINEER

Two pumping-stations are proposed for the Suffolk County transportation works; one at the westerly end of the main aqueduct near the site of the present Ridgewood stations to pump the entire Suffolk County supply into the distribution system of Brooklyn and other boroughs; the other station near Riverhead to lift the Peconic Valley waters over the hill to the main south shore aqueduct.

RIDGEWOOD PUMPING-STATION

It is proposed to place the pumping-station and the coal storage plant on the southerly end of the land owned by The City, on the south side of Atlantic avenue, and in part occupied by the Ridgewood new pumping-station, as shown on Sheet 108, Acc. 5041. The pumps of this present station have been in operation some years; they are not efficient and require frequent repairs, so that the whole station could well be abandoned on the completion of the large pumping-station here proposed, and the land fronting on Atlantic avenue devoted to park purposes, or utilized in the future for another station.

Type of Machinery for Station Equipment

The normal capacity of the station would be 250 million gallons daily, the maximum capacity 300 million gallons daily, and the supply would be pumped against a distribution pressure in the City mains estimated for the future at 220 feet on the B. W. S. datum. The station would be equipped for the complete development with 8 high-duty vertical triple-expansion fly-wheel engines, each having a normal capacity of 35 million gallons daily, and a maximum delivery of 42 million gallons daily. With a steam pressure of 150 pounds per square inch, the size of each engine would be about 42 inches and 73 inches and 110 inches by 40¾ inches by 72 inches stroke, piston speed 240 feet per minute.

Steam would be supplied by 5 batteries of water-tube boilers each 1000 H.P., of which one would be a reserve. All boilers would be fitted with mechanical stokers, fed by weighing hoppers which receive coal from bins above the boilers.

The coal would be carried from a coal storage building to these bins by a conveyor, which would also remove the ashes. The capacity of the coal storage building would be about 10,000 tons, and that of the bins over the boilers about 3,000 tons, making a total of 13,000 tons. This would be sufficient for 75 days' run when completed station is running at average capacity.

The general lay-out of the engine room and boiler house of the proposed plant is shown on Sheet 109, Acc. 5043, and that of the coal storage building on Sheet 110, Acc. 5042.

Station Buildings

The buildings for the proposed plant would be constructed in a plain, substantial manner, with sufficient ornament to make them an attractive feature of the great thoroughfare within the City limits on which they would be located.

Progressive Equipment of Station

The proposed collecting works in Suffolk county would be constructed in successive stages and the pumping-station at Ridgewood need only be equipped at any stage with a sufficient number of boilers and engines to pump the maximum yield of the collecting works at that time. The buildings, stack, coal storage, coal conveyor, the foundations for all boilers and engines and the pump-well, would be complete at the first installation.

The equipment of the station for the first three stages of the Suffolk County development is estimated as follows:

Stages of Development	Normal Pumpage of Stations in Million Gallons Daily	Maximum Pumpage During Months of Large Demand in Million Gallons Daily	Total Number of Boilers	Number of Pumping Engines
1.............	70	120	2	4
2.............	150	240	4	7
3.............	220	300	5	8

On the completion of the third stage, the station would have a capacity equivalent to that of the proposed Suffolk County aqueduct and no further additions need be made, as the collecting works are pushed on into Suffolk county.

Estimated Cost of Station

The pumping-station is estimated to cost as follows, complete with station buildings, coal handling plant, and foundations for entire equipment. No allowance is made at this point for engineering and contingencies:

Stage of construction	Total cost
1	$1,977,900
2	2,543,000
3	2,738,500

The detailed estimates of cost of the complete Ridgewood station are shown below. Except as noted, excavation for foundations has been estimated at $1.50 per cubic yard. Concrete has also been figured at $8.00 per cubic yard.

COST OF RIDGEWOOD PUMPING-STATION

	FOUNDATIONS			
Engines, boilers, economizers and tunnels under boilers, and between buildings	4,175 cubic yards	concrete		$33,400
	6,100 " "	excavation		9,150
Stack	275 " "	concrete		2,200
	380 " "	excavation		570
Water intake	1,780 " "	concrete		14,200
	16,250 " "	excavation		24,400
Main Building	3,550 " "	concrete		28,400
	27,500 " "	excavation at $1.25		34,500
Coal storage building	1,500 " "	concrete		12,000
	3,000 " "	excavation		4,500
				$163,320
	BUILDINGS			
Pumping-station			$703,000	
Coal storage			211,511	
				$914,500
	EQUIPMENT			
Eight 35 million gallons daily pumping-engines			$1,400,000	
Suction and discharge pipes			28,500	
Steam piping and covering			15,400	
5,000 H.P. of boilers			101,000	
Boiler feed pumps			1,000	
Economizers			26,500	
Stack			8,900	
Coal handling equipment			60,000	
Traveling crane			7,400	
Electrical equipment			12,000	
				$1,660,700
Total				**$2,738,500**

The total cost of coal storage plant may possibly be reduced by the installation of a Dodge coal storage system somewhat similar to that used at present by the New York Edison Company, at Shady Side, N. J., and the Nassau Light and Power Company, Glenwood, N. J. These are described in the Engineering Record of May 13, 1905, and April 14, 1906.

Cost of Operating Plant

In order to make a safe estimate of the daily station duty of a pumping-plant of this size, it was deemed advisable before working up these preliminary designs, to study the pumping statistics of some of the large cities of the United States. In all, 17 different city reports have been carefully gone over, and, where possible, the station duty of the two different types of high-duty pumps (direct acting and crank fly-wheel) has been tabulated.

The City of New York has no modern high-duty pumps such as are installed by many other cities; the prevailing type in use is the Worthington direct acting pump with high-duty attachment. At the 179th Street station there are four old style crank and fly-wheel pumps made by the Blake Manufacturing Company, but the duty of these engines is very little, if any, better than that of the two Worthington high-duty pumps in the same station.

Table 30 is a tabulation of the station duties of several cities, each having Worthington high-duty pumps. This table shows that the New York pumps are doing better work per 100 pounds of coal than those of the same design in other cities, indicating that the pumps here are in good condition and under good management. Referring to Table 31 it will be seen that the Worthington pumps in New York are doing as well, and better in some cases, than the more expensive fly-wheel pumps in some other cities. The cause of poor results shown by fly-wheel engines in these cities is bad management and neglect, as there is no reason why they should not do better than the direct acting engines.

Table 32 shows a list of high-duty vertical triple expansion fly-wheel engines, which, with one exception, have a duty of 100 million foot pounds or over for each 100 pounds of coal. These are all modern engines except the Blake pump in Toronto.

In order to arrive at a safe station duty for the proposed Ridgewood system we should consider the following facts:

(1) Proposed pumps are of large capacity (35 million gallons daily each) and are estimated to work against a high head (220 feet).

(2) Steam would be furnished by water-tube boilers in batteries of 1000 H.P. each. Two boilers would make up one battery, instead of a large number of

TABLE 30

City	Station	Capacity of Pumps	Head	[illegible] of Coal	Kind of Coal	Cost of Coal	Cost of 1 Mg 1' high	Reference	Remarks
New York	Jerome Park	10 Mgd	173.9'	77,511,208	Anthracite	$6.20	$0.0682	Annual Report 1905	
	179th St	5 @ 10 Mgd	108 to 236'	81,683,264	"	$5.09	$0.049	" " "	Includes Blake Triples
	Ridgewood No	Report							
Minneapolis	Station No. 3	12½ Mgd	238.5'	71,434,161	Sawdust		$0.04467	" " 1906	Compound
		"	"	71,322,215	"				
Providence			174.5'	78,545,307	New River Semi-Bitum's	$4.17		" " 1906	
Chicago	Central Park Ave.	20 Mgd	101.01'	58,500,000	Bituminous Run of Mine	$2.20	$0.0348	" " 1906	
	Springfield Ave.	20 "	105.3'	57,604,000	"	$2.15	$0.0339	" " 1906	
Philadelphia	Roxborough High Serv.	5 Mgd	129'	36,200,000	Anthracite Pea	$3.40	$0.144	" " 1907	High Ratio Compd.
Reading	Maiden Creek Pumps No. 1, & No. 2.	5 Mgd 10 "	239.9' 263.6'	46,401,282 68,965,997	Bituminous	$2.63	—	" "1905-07	1 Compd. Very old 2 High Duty Triple

B.W.S. 388

City of New York
BOARD OF WATER SUPPLY
DATA ON DIRECT ACTING ENGINES
OF WORTHINGTON & SIMILAR TYPES
HIGH DUTY

TABLE 31

City	Station	Capacity of Pumps	Head	Station Duty per 100 Lbs of Coal	Kind of Coal	Cost of Coal	Cost of 1 Mg 1' high	Reference	Remarks
Buffalo		30 Mgd	129'	71,667,400	Bituminous	$2.05		Annual Report 1907	Lake Erie Eng. Wks.
		30 "	"	71,660,600	"				" " " "
Minneapolis	Station No. 4	15 Mgd	236.4'	89,415,462		$3.27	$0.03782	" " 1906	
		"	"	82,775,024					
Chicago	14th Street	15 Mgd 30 "	111.7'	68,200,000	Bituminous Run of Mine	$2.50	$0.0290	" " 1906	Allis-Chalmers Lake Erie Eng. Wks.
	Harrison St.	15 "	107.54'	61,800,000	Bituminous	$2.40	$0.04	" " "	Allis-Chalmers.
Philadelphia	Frankford No. 2.	20 Mgd	191'	81,300,000	Bituminous	$2.97	$0.029	" " 1907	Holly
St. Louis	High Serv. Baden	15 Mgd	292.64'	78,700,000	Bituminous	$1.58	$0.01928	" " 1906	Allis
	High Serv. Bissels Pt.	20 Mgd	239.07'	80,200,000	"	$1.58	$0.0394	" " "	Allis Chalmers. [illegible]

B.W.S. 387

All triple expansion

City of New York
BOARD OF WATER SUPPLY

DATA ON HIGH DUTY CRANK & FLYWHEEL ENGINES
GIVING LOW STATION DUTY

TABLE 32

City	Station	Capacity of Pumps	Head	Station Duty per 100 Lbs. of Coal	Kind of Coal	Cost of Coal	Cost of 1 Mg 1' high	Reference	Remarks
Boston	Chestnut Hill High Service Engs. No 3 & 4	30 Mgd	131.5'	132,660,000	Anthracite & Bituminous	\$2.93 \$4.26	\$0.027	Annual Report 1907	Leavitt Allis
	Chestnut Hill Low Service	35 Mgd	51.15'	101,430,000	"	\$2.84 \$4.12	\$0.033	" " "	Holly
	Spot Pond	20 "	127.9	127,620,000	"	\$2.24 \$4.36	\$0.031	" " "	Holly
Providence				144,947,660	New River Semi-Bitum's	\$4.17		" " 1906	Allis-Chalmers
Louisville	New Station		190'	122,600,000	Bituminous				
Reading, Pa.	Maiden Creek	15 Mgd	292.5'	117,446,134	"	\$2.63	–	" " 1906-07	
Toronto			231'	82,000,000	"				Blake Engines similar to 179th St
			237.5'	100,050,000					John Inglis
Cleveland	Kirtland St. #2 #3	35 Mgd	181.8' 223	107,300,000	Bituminous Pittsburg slack	\$1.70	–	Computed from Annual Report 1905	Holly
Detroit		25 "	120'	121,000,000	Bituminous Run of Mine	\$2.34	–	Computed from Annual Report 1906	Allis-Chalmers.

B.W.S. 448

All triple expansion

City of New York
BOARD OF WATER SUPPLY

DATA ON HIGH DUTY CRANK & FLYWHEEL ENGINES GIVING HIGH STATION DUTY

small boilers, as at present in many stations of New York City.

(3) Boilers would be fired by mechanical stokers.

(4) The City uses a good grade of coal (broken anthracite).

(5) The good showing per 100 pounds of coal made by New York high-duty pumps.

(6) This would be the largest pumping-station in America, and would contain the largest pumping-engines ever built in this country, about 1450 indicated horse power each. It would, no doubt, be an exhibition station. Such being the case, the machinery would receive better care than that of an ordinary pumping-plant.

(7) A growing tendency toward higher test and station duties in many cities, due to better machinery, better engineers and the higher price of coal.

In view of the foregoing, and the results shown in Table 32, the writer thinks that it is within the limits of safety to assume a station duty of 115 million foot pounds per 100 pounds of coal.

In estimating the cost of operating the proposed station at the above duty, the following force of engineers and assistants is assumed to be employed when the station would be completely equipped. Salaries are based upon those now paid at the Ridgewood station of the Brooklyn works:

1	Chief Engineer		$2,500
3	Assistant Engineers at $1,800 per annum		5,400
1	Clerk		1,500
24	Enginemen at $4.00 per day		35,040
24	Oilers at $3.00 per day		26,280
4	Cleaners at $2.00 per day		2,920
16	Water and coal tenders at $3.00 per day		17,520
1	Carpenter at $1,500 per annum		1,500
1	Painter at $4.00 per day		1,252
2	Machinists at $4.00 per day		2,505
2	Machinists helpers at $2.50 per day		1,564
1	Steam fitter at $3.50 per day		1,092
1	Steam fitter helper at $2.50 per day		782
1	Foreman of Laborers at $3.00 per day		936
8	Laborers at $2.00 per day		5,008
90	Total		**$105,797**
	Oil and waste	$5,000	
	Miscellaneous supplies	5,000	
	Repairs to pumps, boilers, stokers, coal conveyors, etc., buildings and grounds	35,000	**45,000**
	65,100 tons of coal at $4.95 per ton		322,245
	Total		**$473,042**
	Cost of pumping 1 million gallons 1 foot high from above figures is (This cost per million foot-gallons does not include interest on investment nor depreciation)		$0.0237
	For safety, this figure has been increased in final estimates to		$0.025

It is interesting to compare this estimated cost with the published costs of pumping in other cities, which are shown in Table 33. Evidently other large high-duty engines have shown much greater economy than here estimated, and a lower figure than the above should be realized.

Sheets 106 and 107, Accs. 5292 and 5308 show estimated costs of pumping 105, 210, and 250 million gallons daily at Ridgewood and at the alternate site at Fresh creek. In making estimates of cost of coal at the proposed Ridgewood station, a price of $4.95 is assumed; this is the amount The City is now paying for coal delivered by rail at this site. Smaller sizes of anthracite might be used and thus effect much economy in operation, but the above figure is adopted to be on the safe side.

ALTERNATIVE SITE FOR STATION AT FRESH CREEK

For comparison with the project for a station at Ridgewood, another site has been investigated at the head of Fresh creek, north of Canarsie, where tide-water coal could be secured by some expenditure for dredging. The location suggested for this station is shown on Sheet 111, Acc. 5039. The general arrangement of the engine room and boiler house, and the coal storage plant which has been worked out in some detail, does not differ much from that of the Ridgewood station and is not reproduced here.

The Fresh Creek site offers some economy in operation because of cheaper coal at tide water. Mr. Rudolph Reimer, who furnishes the coal for the present Ridgewood station, states that he could deliver coal by water at the Fresh Creek site alongside for $4.55 per ton, but estimates are based on $4.60 per gross ton. Furthermore, the adoption of the Fresh Creek location would avoid the heavy excavation for the aqueduct on the Ridgewood line west of Pitkin avenue, and would also avoid the danger during construction of interrupting the supply in the present conduits running to the existing Ridgewood stations. There would also be some saving at the Fresh Creek site in shorter force mains to the trunk distribution mains, but these savings would, in a measure, be offset by a longer aqueduct to Fresh creek, by the cost of siphons under the large trunk sewers on this line, expenditures for land for the station, and by the cost of dredging out a chan-

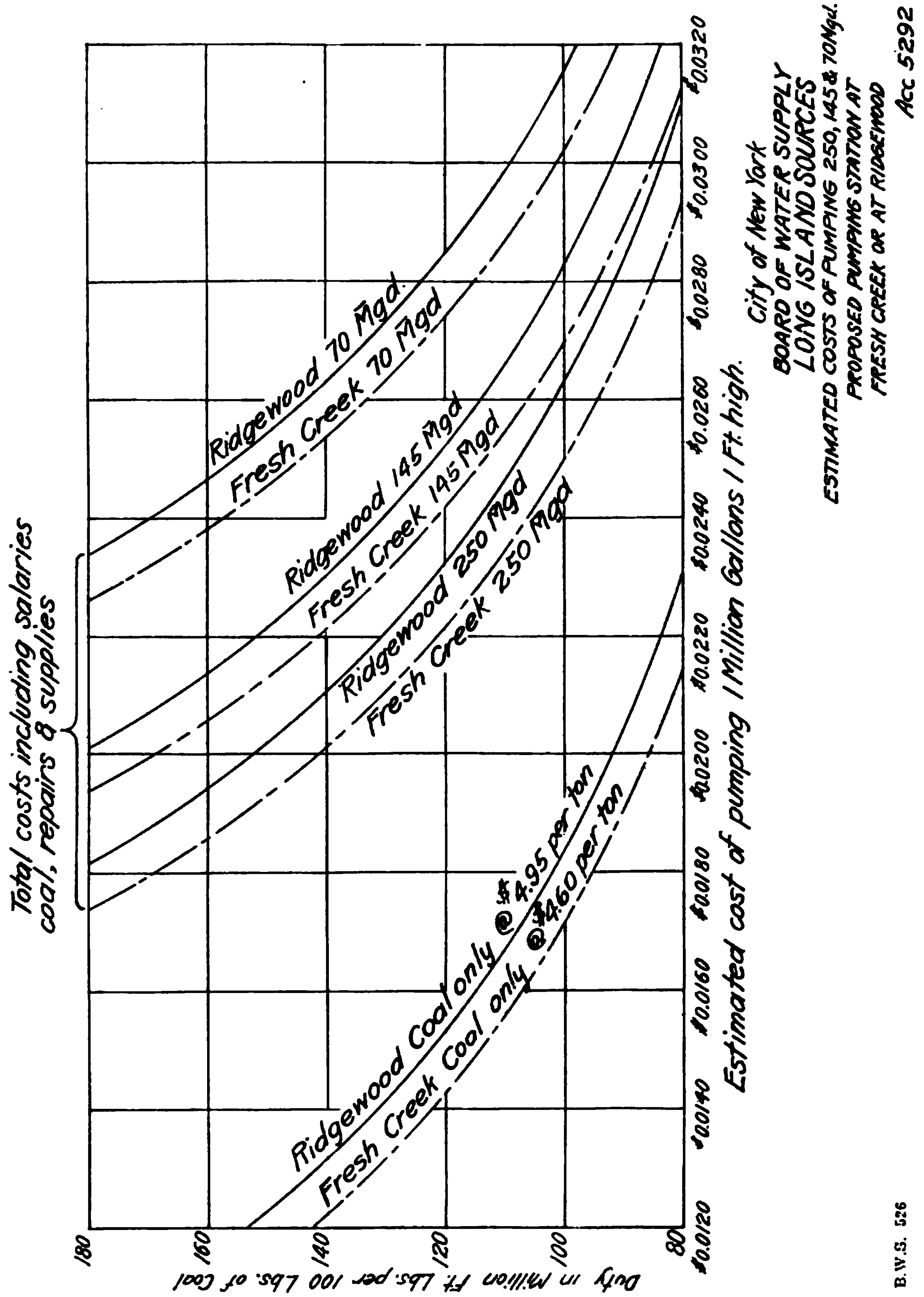
TABLE 33

City	Station	Total Capacity	Cost of Coal per Gross Ton	Cost per Mg. 1' high
	Chestnut Hill			
	High Service Eng. #4	66 Mgd.	\$4.01	\$0.022
Boston	Chestnut Hill			
	Low Service	105 "	\$3.82	\$0.033
	Spot Pond	30 "	\$3.97	\$0.031
	98th Street	Av. 16.6 "	\$5.29	\$0.0964
New York	179th Street	" 5.7 "	\$5.09	\$0.049
	Jerome Ave.	" 9. "	\$6.20	\$0.0682
	Roxborough			
Philadelphia	High Service	10 "	\$3.40	\$0.1444
	Frankford #2	60 "	\$2.94	\$0.029
Pittsburgh	Brilliant	80 "	\$1.60	\$0.019
Buffalo	Eng. #8	30 "	\$2.20	\$0.035
Reading Pa.	Maiden Creek	30 "	\$2.63	\$0.021
	Front Street	Daily Av.		
Cincinnatti	Low Service	7.8 Mgd.	\$2.37	\$0.1116
	Middle "	43.1 "		\$0.0843
Cleveland	Kirtland Street		\$1.846	\$0.02080
Dayton, O.		35 "	\$2.50	\$0.0225
	14th Street	75 "	\$2.50	\$0.0287
	Harrison Street	30 "	\$2.40	\$0.0391
Chicago	Springfield Ave.	100 "	\$2.15	\$0.0328
	Central Park Ave.	100 "	\$2.22	\$0.0330
Minneapolis	Station #3	25 "	\$3.27	\$0.04407
	" #4	30 "		\$0.03782
Detroit		152 "	\$2.38	\$0.0242
	Baden High Service	80 "	\$1.58	\$0.01928
St. Louis	Bissels Point			
	High Service		\$1.58	\$0.0394

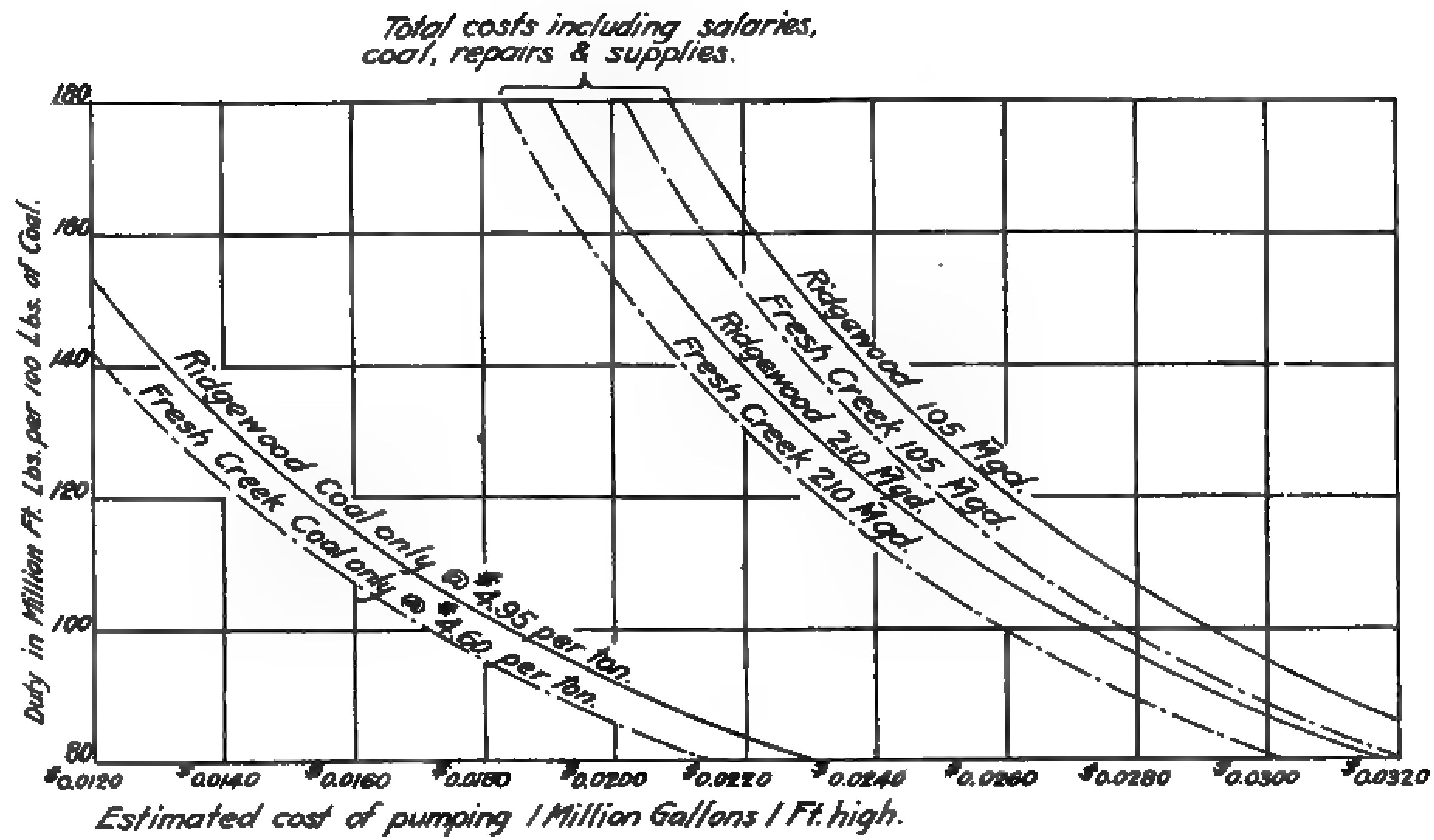
City of New York
BOARD OF WATER SUPPLY
COST OF PUMPING
IN VARIOUS CITIES

B.W.S. 439

SHEET 106



B.W.S. 526



BOARD

LONG ISLAND SOURCES

ESTIMATED COSTS OF PUMPING 210 & 105 Mgd.
PROPOSED PUMPING STATION AT
FRESH CREEK OR AT RIDGEWOOD

Acc 5308

B.W.S. 617

nel in Fresh creek to make it navigable. Sheet 105, Acc. LJ 136, shows design of siphon on this line.

A comparison of the total cost and annual expense of operation at these sites, including the fixed charges on the cost of the complete works is given in the following table, assuming an average pumping of 250 million gallons per day:

COMPARISON OF RIDGEWOOD AND FRESH CREEK SITES
FOR PROPOSED PUMPING-STATION

Items	Proposed Ridgewood Station	Alternative Fresh Creek Station
COST OF AQUEDUCT AND STATION FROM COMMON POINT NEAR FRESH CREEK		
Land	....	$100,000
Pumping-station complete	$2,738,500	2,908,500
Aqueduct and appurtenances	625,620	1,278,840
Force mains	1,437,960	421,280
Engineering and contingencies	960,420	921,720
Total	**$5,762,500**	**$5,630,340**
FIXED CHARGES		
Interest, 4 per cent	$230,500	$225,214
Sinking fund, 0.887 per cent	51,113	49,941
OPERATING EXPENSES		
Extraordinary repairs and depreciation	92,762	73,736
Operation	501,875	479,090
Total annual expenditures	**$876,250**	**$827,981**

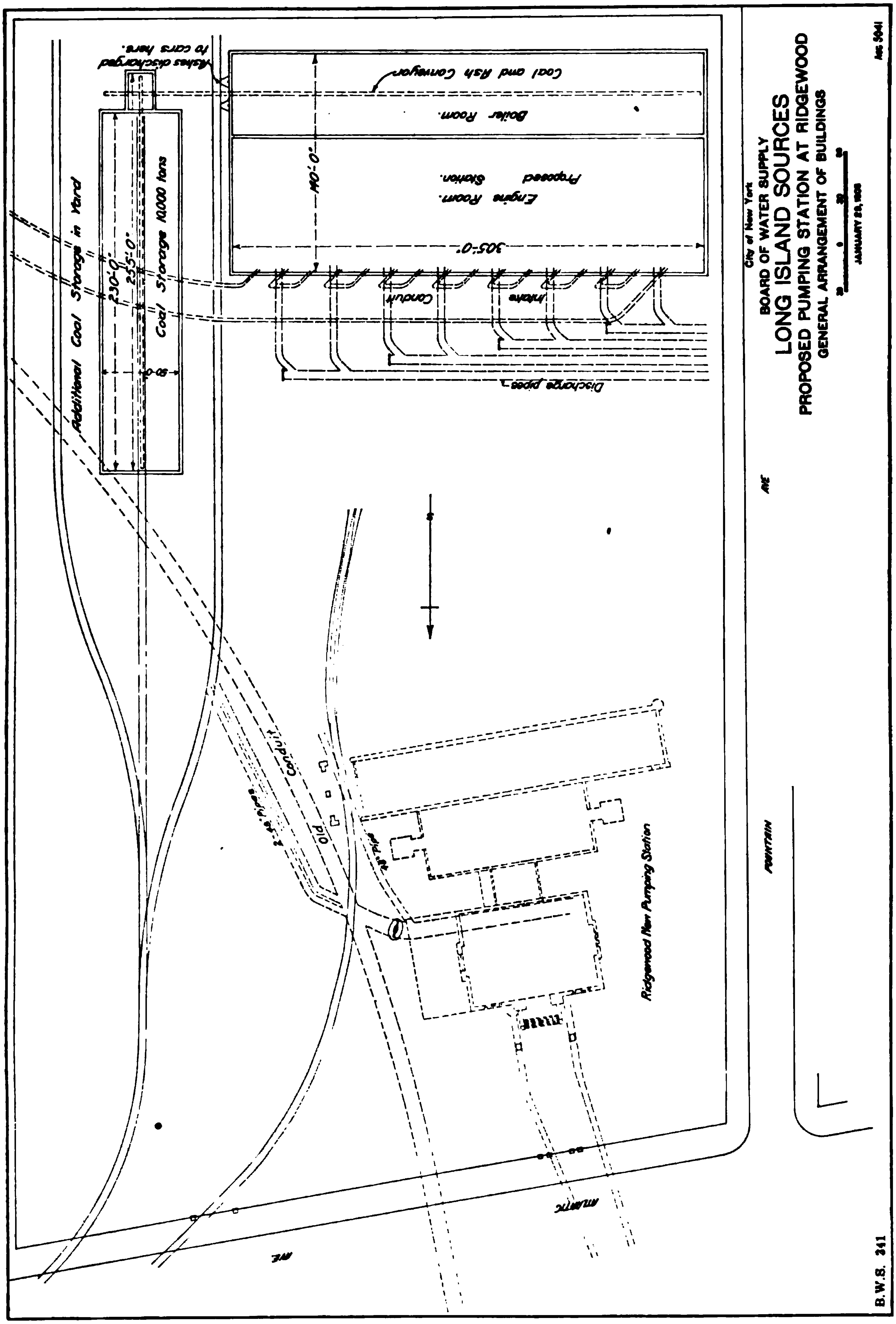
There would evidently be a saving of $48,000 in annual operating expenses in choosing the Fresh Creek site. This, however, would doubtless be reduced by some economy in labor and superintendence at the Ridgewood site in having all the Brooklyn pumping-stations together, so that the actual saving for a year might not exceed $40,000. A part of this saving is due to the shorter force mains from the Fresh Creek station, as estimated in some preliminary studies of a new distribution system, and the final studies may not be as favorable for this site. Furthermore, the estimate on tide-water coal does not include any dredging below Fresh creek, it being assumed that the present channel in Jamaica bay is navigable for coal barges. Perhaps the work of improvement that has been suggested in Jamaica bay would be completed by the time the station was finished. Coal is now brought to Canarsie by water and could doubtless be carried in barges to the station on Fresh creek after the dredging here estimated was done, but unless the work of improvement is taken up, Jamaica bay may not be safely navigable for large barges for

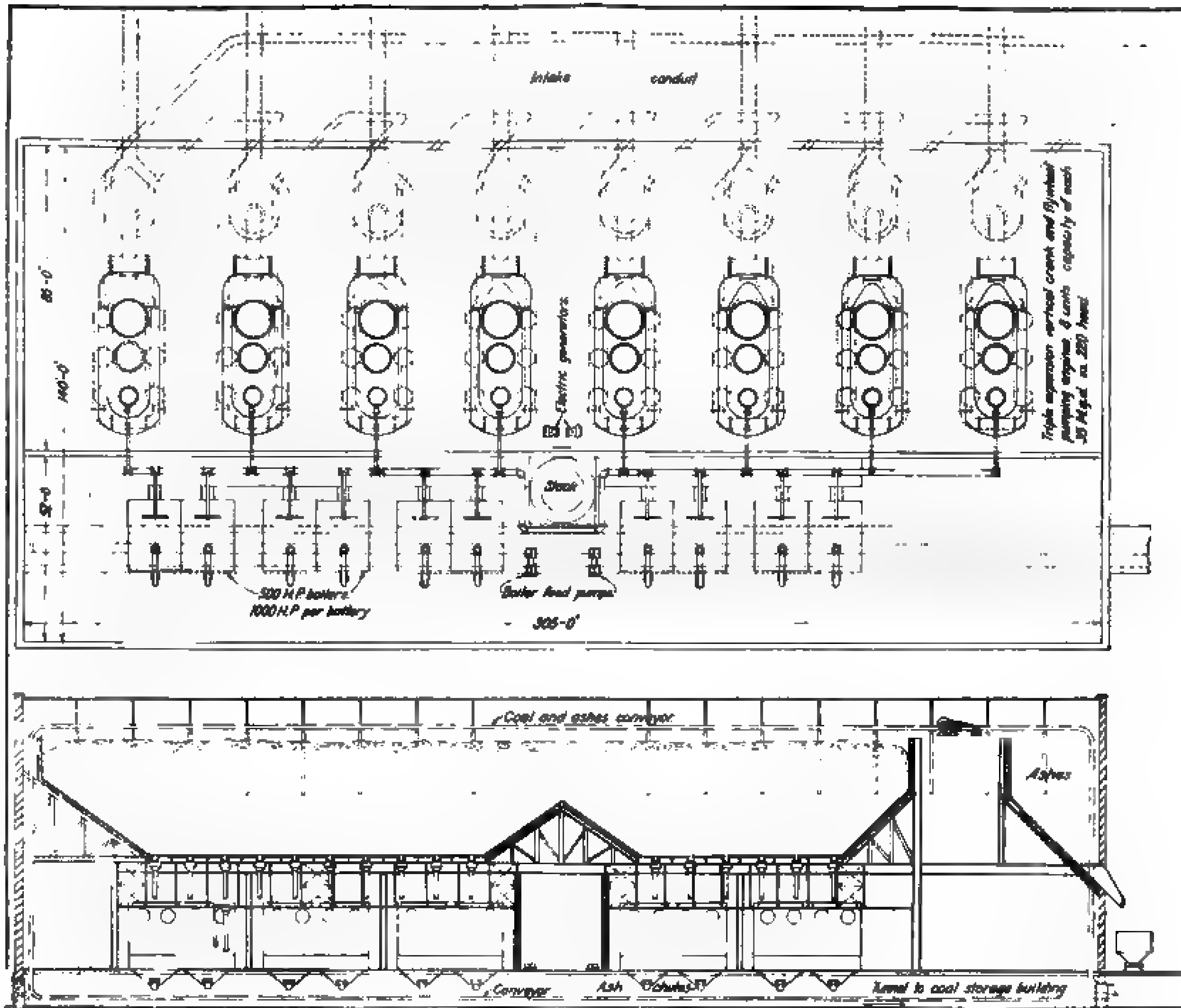
many years. The Ridgewood site is therefore proposed for the preliminary estimates of cost. Further investigation is desirable.

RIVERHEAD PUMPING-STATION

An equipment of centrifugal pumps electrically driven from a central power-station would be installed near Sweezy pond, at Riverhead, at the lower end of the Peconic aqueduct and collecting works. This station is shown on Sheet 112, Acc. 5345, and is estimated to cost, with equipment, $75,000, exclusive of an allowance for engineering and contingencies, which is added in the total estimates. The average supply of 30 million gallons per day (maximum 50 million gallons daily) would be delivered through two 48-inch cast-iron mains, 3¼ miles in length to the summit of the hill towards Westhampton, against a total head, including friction losses, of 70 feet.

SHEET 108

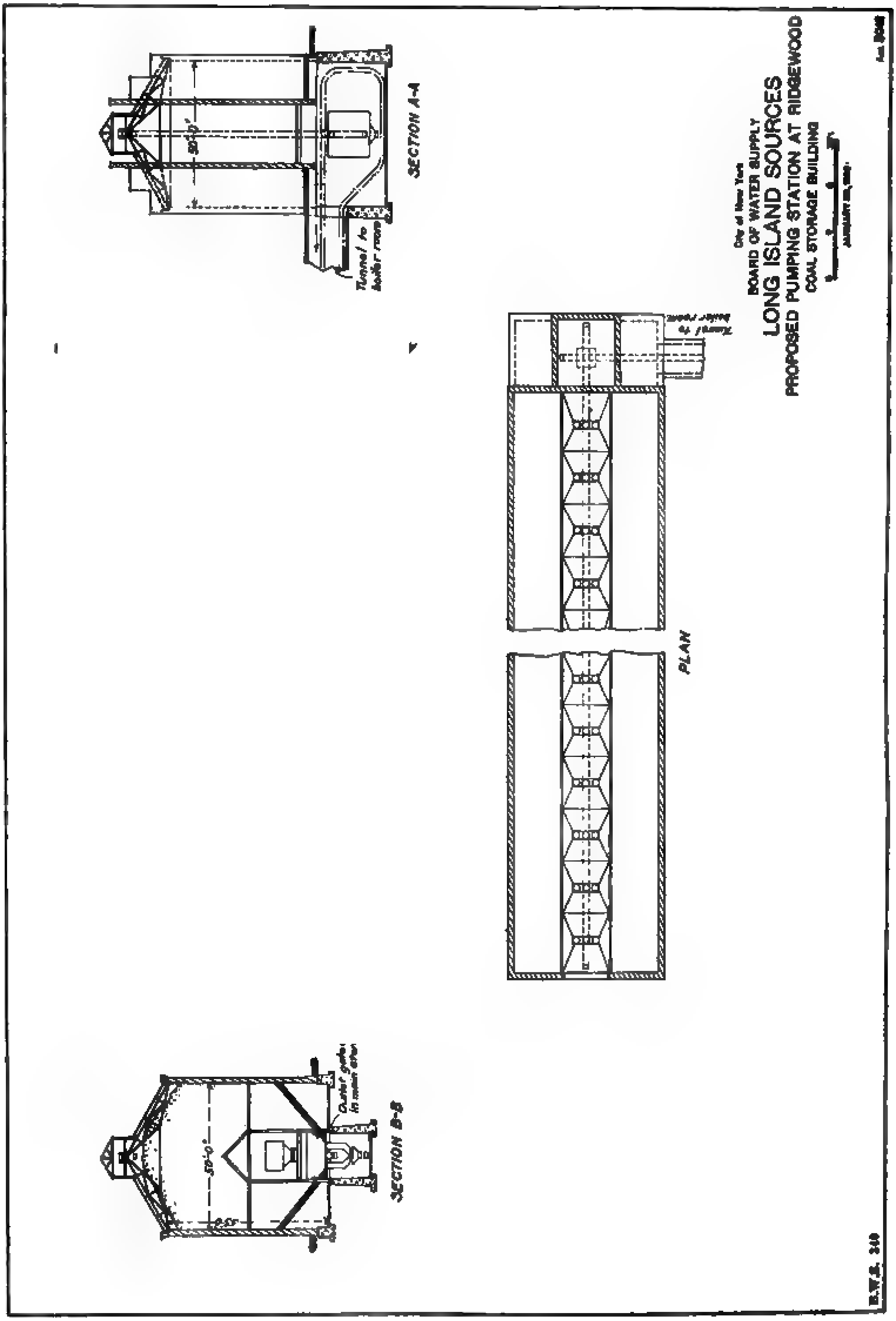

City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED PUMPING STATION AT RIDGEWOOD
GENERAL ARRANGEMENT OF BUILDINGS
Coal and Ash Conveyor
Ashes discharged to cars here.
Boiler Room.
Engine Room.
Proposed Station.
110'-0"
305'-0"
Additional Coal Storage in Yard
Coal Storage 10,000 tons
230'-0"
255'-0"
Conduit
Intake
Discharge pipes
Old Conduit
Ridgewood New Pumping Station
FOUNTAIN
AVE
ATLANTIC
AVE
B.W.S. 341

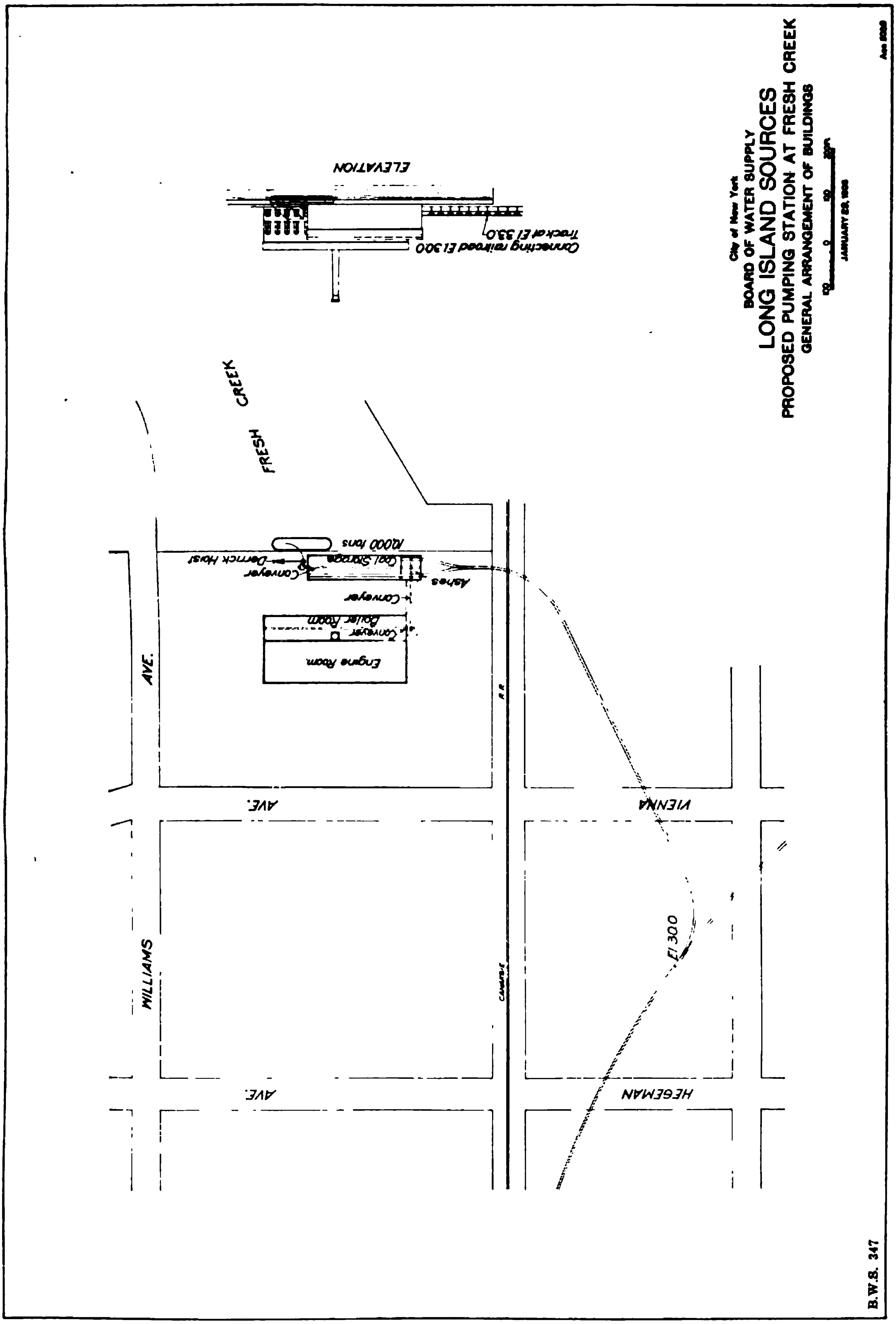


LONGITUDINAL SECTION
OF BOILER ROOM

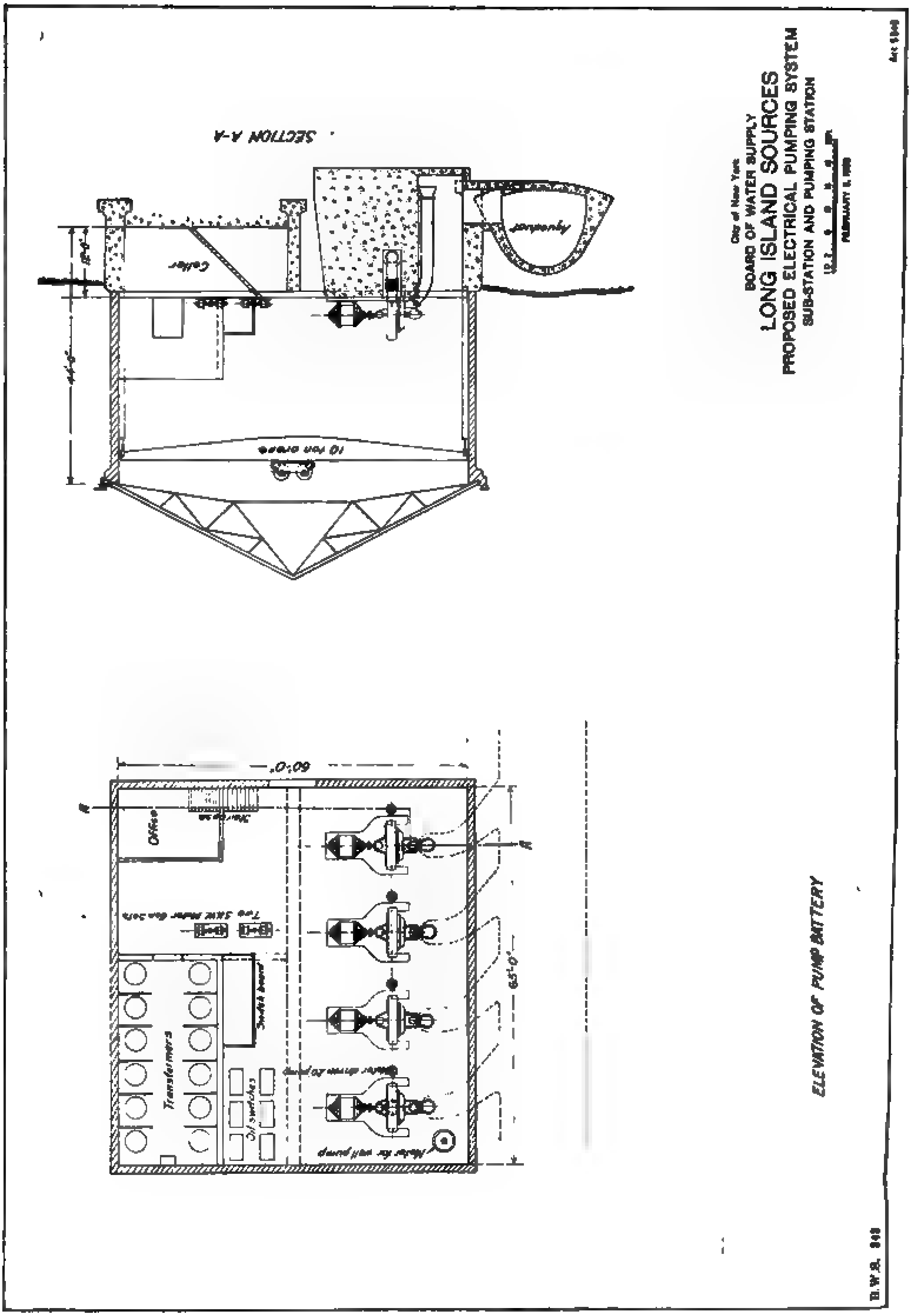
City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED PUMPING STATION
AT RIDGEWOOD

H.W.S. 349


SECTION A-A
Tunnel to boiler room
50'-0"
SECTION B-B
PLAN
City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED PUMPING STATION AT RIDGEWOOD
COAL STORAGE BUILDING
B.W.S. 240


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED PUMPING STATION AT FRESH CREEK
GENERAL ARRANGEMENT OF BUILDINGS
ELEVATION
Connecting railroad El 30.0
Track at El 33.0
FRESH CREEK
10,000 tons
Coal Storage
Derrick Hoist
Conveyer
Ashes
Conveyer
Boiler Room
Conveyer
Engine Room
WILLIAMS AVE.
AVE.
VIENNA
HEGEMAN
AVE.
El 30.0
B.W.S. 347

SHEET 112



City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
PROPOSED ELECTRICAL PUMPING SYSTEM
SUB-STATION AND PUMPING STATION
SECTION A-A
10 ton crane
Cellar
Office
Transformers
Oil switches
Switch board
Motor driven pump
Motor for well pump
60'-0"
65'-0"
ELEVATION OF PUMP BATTERY

APPENDIX 11

COST OF SUPPLY FROM THE PROPOSED SUFFOLK COUNTY WORKS

BY WALTER E. SPEAR, DIVISION ENGINEER

The items of cost of the proposed Suffolk County works, which are discussed in detail in the several appendices of this report, are assembled in this chapter and the probable cost of the supply computed. The estimates on land and water damages have been based upon the payments of the Department of Water Supply in Nassau county during the past few years, making a liberal allowance for surveys and legal expenses. In all items of cost, 20 per cent. has been added to cover engineering and unforeseen contingencies. The various estimates given in this appendix are summarized and compared in the main report, pages 93 to 101.

COST OF WORKS FOR 250 MILLION GALLONS PER DAY

As already noted in the preceding pages, the Suffolk County works would be constructed in successive stages, at intervals of five or six years, as required to meet the growing consumption of the City. Before the first stage of construction could be completed, the long aqueduct built from Suffolk county to Brooklyn borough, and the pumping-station erected at Ridgewood, it would be possible, upon the extension of the proposed 72-inch pipe-line to Massapequa and the erection of the proposed pumping-station at that point by the Department of Water Supply, to deliver, perhaps, 50 million gallons per day to Brooklyn through the Ridgewood system. Estimates have therefore been made on a preliminary stage of the Suffolk County works, which might be completed within two years after the time of beginning work, to furnish an emergency supply for Brooklyn borough.

The works required to deliver this emergency supply from Suffolk county through the Ridgewood system would comprise the first 10 miles of the aqueduct and collecting works, easterly from the Nassau-Suffolk County line, a temporary power-station near Babylon, about two miles of the main

aqueduct from the Suffolk County line to Massapequa Supply pond, and a connection on the east side of this pond from the aqueduct to the proposed station of the Department of Water Supply at Massapequa.

The extent to which the proposed Suffolk County system would be completed at each stage of construction is summarized below:

Stage	Average Supply for New York City Million Gallons Daily	Extent of Works Constructed for This Stage
Preliminary..	50	Construction of 10 miles of aqueduct and collecting works from Nassau County line to Bayshore. Temporary power-plant and 2 miles of main aqueduct from Suffolk county to Massapequa with connection to Ridgewood system
1..........	70	Completion of main aqueduct from Suffolk county to Brooklyn borough and pumping-station near Ridgewood with equipment for pumping 120 million gallons daily. Extension of aqueduct and collecting works in Suffolk county to Great River, 14.7 miles from Nassau County line, and construction of permanent power-station near Patchogue
2..........	150	Extension of aqueduct and collecting works from Great River to South Haven, 29.5 miles from Nassau County line. Installation equipment for pumping 240 milliongallons daily
3..........	220	Extension of aqueduct and collecting works from South Haven to the end of the south shore development at Quogue, 48.4 milesfrom Nassau County line. Completion of equipment for pumping 300 million gallons daily
4..........	250	Construction of aqueduct and collecting works in the Peconic valley, the pumping-station near Riverhead, and the force mains and aqueduct from this station to the south shore aqueduct at Westhampton
5..........	250	Completion of entire works by building the aqueducts and collecting works on the three branch lines into the center of the island

COST OF WATER FROM THESE WORKS

The cost of these works at the several stages, and the corresponding cost of the supply per million gallons, which have been summarized in Table 2, page 99, is shown in detail in Table 34. The estimates of the annual charges, shown in this table, include the fixed charges and the entire operating expenses at each stage. From the annual expenditures on each project, the cost of each million gallons of the total supply delivered into the mains of Brooklyn against the full distribution pressure has been found. This figure represents the probable actual cost to the taxpayer of each million gallons supplied from the Suffolk County sources, exclusive of the charges on the distribution system.

TABLE 34

ESTIMATES OF COST OF SUFFOLK COUNTY WORKS AND TOTAL ANNUAL EXPENDITURES AND COST OF WATER BASED UPON FIXED CHARGES AND OPERATING EXPENSES. PROJECT FOR PERMANENT SUPPLY OF 250 MILLION GALLONS DAILY. PRELIMINARY STAGE. AVERAGE SUPPLY OF 50 MILLION GALLONS DAILY

	Cost	Taxes		Extraordinary Repairs and Depreciation	
		Rate Per Cent.	Amount	Rate Per Cent.	Amount
COLLECTING WORKS					
Well system					
Wells	$63,600	....	....	5.0	$3,180
Pumps, motors, concrete chambers below ground, control and all connections	226,000	....	....	5.0	11,300
Transmission system substations					
Substation buildings	30,000	1.5	$450	2.0	600
Equipment	51,000	....	....	4.0	2,040
Line, poles, wire, etc	90,000	1.0	900	3.0	2,700
Telephones	3,000	1.0	30	3.0	90
Central power-station					
Buildings above ground and stack	15,000	1.5	225	25.0	3,750
Equipment	235,000	....	....	3.5	8,225
Land for right-of-way, borrow-pits, spoil-banks and roads	1,027,000	1.0	10,270	....	.....
Land and water damages	500,000	....	....	....	.....
Highways	400,000	....	....	5.0	20,000
Fencing and special improvements	220,000	....	....	2.0	4,400
Infiltration basins for utilization of surface flood waters	276,500	0.4	1,106	0.1	277
Conduits for diversion of water to streams and ponds. Lowering of ponds and necessary changes in lieu of damages	165,000	....	....	2.0	3,300
Engineering and contingencies, 20 per cent	660,420	....	....	....	.....
Total	**$3,962,520**	....	**$12,981**	....	**$59,862**
TRANSPORTATION WORKS					
Pumping-stations; buildings taxed outside City limits	$5,000	1.5	$75	2.0	$100
Aqueduct lines					
Lands in Nassau and Queens	62,000	1.0	620	....	.....
Aqueduct, including earth work, masonry and earth embankment at wells	2,478,000	....	....	0.1	2,480
Special structures					
Above ground	5,000	1.0	50	2.0	100
Below ground	55,000	....	....	1.0	550
Fencing and special improvements, Queens and Nassau	38,000	....	....	2.0	760
Land damages, Queens and Nassau	15,000	....	....	....	.....
Engineering and contingencies, 20 per cent	532,000	....	....	....	.....
Total	**$3,190,000**	....	**$745**	....	**$3,990**

ANNUAL CHARGES

	Collecting Works	Transportation Works
Interest on total cost at 4 per cent	$158,500	$127,600
Sinking fund to pay bonds at end of 50 years, interest at 3 per cent. (0.887 per cent. of cost per year)	35,100	28,300
Taxes and special assessments	13,000	740
Extraordinary repairs and depreciation	59,900	4,000
Operating expenses and maintenance	128,300	133,860
Totals	**$394,800**	**$294,500**
Grand total		**$689,300**
Total amount of water supplied in million gallons, 365 x 50 =		18,250
Cost of supply per million gallons		$37.77

No reservoirs required in preliminary stage on salt-water estuaries and no land outside of aqueduct right-of-way required for central power-station. No temporary works in this stage.

TABLE 34 (*Continued*)

Estimates of Cost of Suffolk County Works and Total Annual Expenditures and Cost of Water Based Upon Fixed Charges and Operating Expenses. Project for Permanent Supply of 250 Million Gallons Daily. Stage 1. Average Supply of 70 Million Gallons Daily

	Cost	Taxes: Rate Per Cent.	Taxes: Amount	Extraordinary Repairs and Depreciation: Rate Per Cent.	Extraordinary Repairs and Depreciation: Amount
COLLECTING WORKS					
Well system					
Wells	$81,650	....	....	5.0	$4,083
Pumps, motors, concrete chambers below ground, control and all connections	334,000	....	....	5.0	16,700
Transmission system substations					
Land outside right-of-way	83,000	1.0	$830	....	.....
Substation buildings	42,000	1.5	630	2.0	840
Equipment	68,000	....	....	4.0	2,720
Line, poles, wire, etc.	118,000	1.0	1,180	3.0	3,540
Telephones	4,200	1.0	42	3.0	126
Central power-station					
Land	10,000	1.0	100	....	.....
Buildings					
Above ground	658,000	1.5	9,870	2.0	13,160
Foundations	64,000	....	....	1.0	640
Equipment	293,000	....	....	3.5	10,250
Land for right-of-way, borrow-pits, spoil-banks and roads	1,819,000	1.0	18,190	....	.....
Land and water damages	735,000	....	....	....	.....
Highways	578,000	....	....	5 0	28,900
Fencing and special improvements	266,000	....	....	2.0	5,320
Infiltration basins for utilization of surface flood waters	276,500	0.4	1,106	0.1	277
Conduits for diversion of water to streams and ponds. Lowering of ponds and necessary changes in lieu of damages	200,000	....	....	2.0	4,000
Temporary works, preliminary stage	15,000	....	....	....	.....
Engineering and contingencies, 20 per cent.	1,129,070	....	....	....	.....
Total	**$6,774,420**	....	**$31,948**	....	**$90,556**
TRANSPORTATION WORKS					
Pumping-stations					
Buildings taxed outside City limits	$1,078,000	1.5	$16,170	2.0	$21,560
Equipment	885,000	....	....	3.5	30,975
Aqueduct lines					
Lands in Nassau and Queens	634,000	1.0	6,340	....	.....
Aqueduct, including earth work, masonry and earth embankment at wells	8,861,000	....	....	0.1	8,861
Special structures					
Above ground	32,000	1.0	320	2.0	640
Below ground	438,000	....	....	1.0	4,380
Fencing and special improvements, Queens and Nassau	327,000	....	....	2.0	6,540
Land damages, Queens and Nassau	153,000	....	....	....	.....
Temporary connection at Massapequa	60,000	....	....	0.1	60
Aqueduct gate-house	5,000	....	....	2.0	100
Engineering and contingencies, 20 per cent.	2,494,600	....	....	....	.....
Total	**$14,967,600**	....	**$22,830**	....	**$73,116**

ANNUAL CHARGES

	Collecting Works	Transportation Works
Interest on total cost at 4 per cent.	$270,980	$598,704
Sinking fund to pay bonds at end of 50 years, interest at 3 per cent. (0.887 per cent. of cost per year)	60,090	132,762
Taxes and special assessments	31,950	22,830
Extraordinary repairs and depreciation	90,560	73,116
Operating expenses and maintenance	155,030	153,000
Totals	**$608,600**	**$980,412**
Grand total		**$1,589,000**
Total amount of water supplied in million gallons, 365 x 70 =		25,550
Cost of supply per million gallons		$62.19

No reservoirs on salt-water estuaries, nor buildings on well system required in first stage.

TABLE 34 (*Continued*)

Estimates of Cost of Suffolk County Works and Total Annual Expenditures and Cost of Water Based Upon Fixed Charges and Operating Expenses. Project for Permanent Supply of 250 Million Gallons Daily. Stage 2. Average Supply of 150 Million Gallons Daily

	Cost	Taxes: Rate Per Cent.	Taxes: Amount	Extraordinary Repairs and Depreciation: Rate Per Cent.	Extraordinary Repairs and Depreciation: Amount
COLLECTING WORKS					
Well system					
Wells	$223,180	....	....	5.0	$11,159
Buildings	5,000	1.5	$75	2.0	100
Pumps, motors, concrete chambers below ground, control and all connections	694,000	....	....	5.0	34,700
Transmission system substations					
Land outside right-of-way	83,000	1.0	830	....	.....
Substation buildings	84,000	1.5	1,260	2.0	1,680
Equipment	129,000	....	....	4.0	5,160
Line, poles, wire, etc	173,000	1.0	1,730	3.0	5,190
Telephones	5,800	1.0	58	3.0	174
Central power-station					
Land	10,000	1.0	100	....	.....
Buildings					
Above ground	658,000	1.5	9,870	2.0	13,160
Foundations	64,000	....	....	1.0	640
Equipment	508,000	....	....	3.5	17,780
Land for right-of-way, borrow-pits, spoil-banks and roads	2,280,000	1.0	22,800	....	.....
Land and water damages	1,485,000	....	....	....	.....
Highways	1,209,000	....	....	5.0	60,450
Fencing and special improvements	438,000	....	....	2.0	8,760
Infiltration basins for utilization of surface flood waters	442,000	0.4	1,768	0.1	442
Reservoirs on salt-water estuaries	301,600	0.2	603	0.2	603
Conduits for diversion of water to streams and ponds. Lowering of ponds and necessary changes in lieu of damages	300,000	....	....	2.0	6,000
Temporary works, preliminary stage	15,000	....	....	....	.....
Engineering and contingencies, 20 per cent	1,821,516	....	....	....	.....
Total	**$10,929,100**	....	**$39,094**	....	**$165,998**
TRANSPORTATION WORKS					
Pumping-stations					
Buildings taxed outside City limits	$1,078,000	1.5	$16,170	2.0	$21,560
Equipment	1,479,000	....	....	3.5	51,765
Aqueduct lines					
Lands in Nassau and Queens	634,000	1.0	6,340	....	.....
Aqueduct, including earth work, masonry and earth embankment at wells	11,885,000	....	....	0.1	11,885
Special structures					
Above ground	51,000	1.0	510	2.0	1,020
Below ground	504,000	....	....	1.0	5.040
Fencing and special improvements, Queens and Nassau	327,000	....	....	2.0	6,540
Land damages, Queens and Nassau	153,000	....	....	....	.....
Engineering and contingencies, 20 per cent	3,222,200	....	....	....	.....
Total	**$19,333,200**	....	**$23,020**	....	**$97,810**

ANNUAL CHARGES

	Collecting Works	Transportation Works
Interest on total cost at 4 per cent	$437,170	$773,328
Sinking fund to pay bonds at end of 50 years, interest at 3 per cent. (0.887 per cent. of cost per year)	96,940	171,485
Taxes and special assessments	39,100	23,020
Extraordinary repairs and depreciation	166,000	97,810
Operating expenses and maintenance	277,250	354,900
Totals	**$1,016,500**	**$1,420,500**
Grand total		**$2,437,000**
Total amount of water supplied in million gallons, 365 x 150 =		54,750
Cost of supply per million gallons		$44.51

TABLE 34 (*Continued*)

ESTIMATES OF COST OF SUFFOLK COUNTY WORKS AND TOTAL ANNUAL EXPENDITURES AND COST OF WATER BASED UPON FIXED CHARGES AND OPERATING EXPENSES. PROJECT FOR PERMANENT SUPPLY OF 250 MILLION GALLONS DAILY. STAGE 3. AVERAGE SUPPLY OF 220 MILLION GALLONS DAILY

	Cost	Taxes Rate Per Cent.	Taxes Amount	Extraordinary Repairs and Depreciation Rate Per Cent.	Extraordinary Repairs and Depreciation Amount
COLLECTING WORKS					
Well system					
Wells	$392,260	....	....	5.0	$19,613
Buildings	7,000	1.5	$105	2.0	140
Pumps, motors, concrete chambers below ground, control and all connections	1,131,000	....	....	5.0	56,550
Transmission system substations					
Land outside right-of-way	83,000	1.0	830	....	.....
Substation buildings	126,000	1.5	1,890	2.0	2,520
Equipment	196,000	....	....	4.0	7,840
Line, poles, wire, etc.	267,000	1.0	2,670	3.0	8,010
Telephones	9,200	1.0	92	3.0	276
Central power-station					
Land	10,000	1.0	100	....	.....
Buildings					
Above ground	658,000	1.5	9,870	2.0	13,160
Foundations	64,000	....	....	1.0	640
Equipment	616,000	....	....	3.5	21,560
Land for right-of-way, borrow-pits, spoil-banks and roads	2,804,000	1.0	28,040	....	.....
Land and water damages	2,427,000	....	....	....	.....
Highways	1,876,000	....	....	5.0	93,800
Fencing and special improvements	581,000	....	....	2.0	11,620
Infiltration basins for utilization of surface flood waters	442,000	0.4	1,768	0.1	442
Reservoirs on salt-water estuaries	819,000	0.2	1,638	0.2	1,638
Conduits for diversion of water to streams and ponds. Lowering of ponds and necessary changes in lieu of damages	475,000	....	....	2.0	9,500
Temporary works, preliminary stage	15,000	....	....	....	.....
Engineering and contingencies, 20 per cent.	2,599,700	....	....	....	.....
Total	**$15,598,200**	....	**$47,003**	....	**$247,309**
TRANSPORTATION WORKS					
Pumping-stations					
Buildings taxed outside City limits	$1,078,000	1.5	$16,170	2.0	$21,560
Equipment	1,661,000	....	....	3.5	58,135
Aqueduct lines					
Lands in Nassau and Queens	634,000	1.0	6,340	....	.....
Aqueduct, including earth work, masonry and earth embankment at wells	14,432,000	....	....	0.1	14,432
Special structures					
Above ground	77,000	1.0	770	2.0	1,540
Below ground	602,000	....	....	1.0	6,020
Fencing and special improvements, Queens and Nassau	327,000	....	....	2.0	6,540
Land damages, Queens and Nassau	153,000	....	....	....	.....
Engineering and contingencies, 20 per cent.	3,792,800	....	....	....	.....
Total	**$22,756,800**	....	**$23,280**	....	**$108,227**

ANNUAL CHARGES

	Collecting Works	Transportation Works
Interest on total cost at 4 per cent.	$623,930	$910,270
Sinking fund to pay bonds at end of 50 years, interest at 3 per cent. (0.887 per cent. of cost per year)	138,356	201,850
Taxes and special assessments	47,003	23,280
Extraordinary repairs and depreciation	247,309	108,227
Operating expenses and maintenance	421,470	499,200
Total	**$1,478,068**	**$1,742,827**
Grand total		**$3,220,900**
Total amount of water supplied in million gallons, 365 x 220 =		80,300
Cost of supply per million gallons		$40.11

TABLE 34 (*Continued*)

ESTIMATES OF COST OF SUFFOLK COUNTY WORKS AND TOTAL ANNUAL EXPENDITURES AND COST OF WATER BASED UPON FIXED CHARGES AND OPERATING EXPENSES. PROJECT FOR PERMANENT SUPPLY OF 250 MILLION GALLONS DAILY. STAGE 4. AVERAGE SUPPLY OF 250 MILLION GALLONS DAILY

	Cost	Taxes		Extraordinary Repairs and Depreciation	
		Rate Per cent.	Amount	Rate Per cent.	Amount
COLLECTING WORKS					
Well system					
Wells	$434,260	....	....	5.0	$21,713
Buildings	7,000	1.5	$105	2.0	140
Pumps, motors, concrete chambers below ground, control and all connections	1,290,000	....	....	5.0	64,500
Transmission system substations					
Land outside right-of-way	83,000	1.0	830	....	.....
Substation buildings	151,000	1.5	2,265	2.0	3,020
Equipment	213,500	....	.....	4.0	8,540
Line, poles, wire, etc	298,000	1.0	2,980	3.0	8,940
Telephones	10,000	1.0	100	3.0	300
Central power-station					
Land	10,000	1.0	100	....	.....
Buildings					
Above ground	658,000	1.5	9,870	2.0	13,160
Foundations	64,000	....	....	1.0	640
Equipment	616,000	....	....	3.5	21,560
Land for right-of-way, borrow-pits, spoil-banks and roads	3,026,000	1.0	30,260	....	.....
Land and water damages	2,642,000	....	....	....	.....
Highways	2,122,000	....	....	5.0	106,100
Fencing and special improvements	642,000	....	....	2.0	12,840
Infiltration basins for utilization of surface flood waters	442,000	0.4	1,768	0.1	442
Reservoirs on salt-water estuaries	819,000	0.2	1,638	0.2	1,638
Conduits for diversion of water to streams and ponds. Lowering of ponds and necessary changes in lieu of damages	515,000	....	....	2.0	10,300
Temporary works, preliminary stage	15,000	....	....	....	.....
Engineering and contingencies, 20 per cent	2,811,550	....	....	....	.....
Total	**$16,869,310**	....	**$49,916**	....	**$273,833**
TRANSPORTATION WORKS					
Pumping-stations					
Buildings taxed outside City limits	$1,108,000	1.5	$16,620	2.0	$22,160
Equipment	1,693,500	....	....	3.5	59,272
Aqueduct lines					
Lands in Nassau and Queens	634,000	1.0	6,340	....	.....
Aqueduct, including earth work, masonry and earth embankment at wells	15,064,000	....	....	0.1	15,064
Special structures					
Above ground	77,000	1.0	770	2 0	1,540
Below ground	618,000	....	....	1.0	6,180
Fencing and special improvements, Queens and Nassau	327,000	....	....	2.0	6,540
Land damages, Queens and Nassau	153,000	....	....	....	....
Engineering and contingencies, 20 per cent	3,934,900	....	....	....	.....
Total	**$23,609,400**	....	**$23,730**	....	**$110,756**

ANNUAL CHARGES

	Collecting Works	Transportation Works
Interest on total cost at 4 per cent	$674,772	$944,380
Sinking fund to pay bonds at end of 50 years, interest at 3 per cent. (0.887 per cent. of cost per year)	149,600	209,420
Taxes and special assessments	49,920	23,730
Extraordinary repairs and depreciation	273,833	110,760
Operating expenses and maintenance	520,070	623,400
Totals	**$1,668,200**	**$1,911,690**
Grand total		**$3,579,900**
Total amount of water supplied in million gallons, 365 x 250=		91,250
Cost of supply per million gallons		$39.23

TABLE 34 (*Concluded*)

ESTIMATES OF COST OF SUFFOLK COUNTY WORKS AND TOTAL ANNUAL EXPENDITURES AND COST OF WATER BASED UPON FIXED CHARGES AND OPERATING EXPENSES. PROJECT FOR PERMANENT SUPPLY OF 250 MILLION GALLONS DAILY. STAGE 5. AVERAGE SUPPLY OF 250 MILLION GALLONS DAILY

	Cost	Taxes		Extraordinary Repairs and Depreciation	
		Rate Per cent.	Amount	Rate Per cent.	Amount
COLLECTING WORKS					
Well system					
Wells	$795,410	....	....	5.0	$39,770
Buildings	7,000	1.5	$105	2.0	140
Pumps, motors, concrete chambers below ground, control and all connections	1,929,000	....	....	5.0	96,450
Transmission system substations					
Land outside right-of-way	83,000	1.0	830	....	.....
Substation buildings	183,000	1.5	2,745	2.0	3,660
Equipment	281,500	....	....	4.0	11,260
Line, poles, wire, etc	340,000	1.0	3,400	3.0	10,200
Telephones	12,500	1.0	125	3.0	375
Central power-station					
Land	10,000	1.0	100	....	.....
Buildings					
Above ground	658,000	1.5	9,870	2 0	13,160
Foundations	64,000	....	....	1.0	640
Equipment	724,000	....	....	3.5	25,340
Land for right-of-way, borrow-pits, spoil-banks and roads	3,917,000	1.0	39,170	....	.....
Land and water damages	3,479,000	....	....	....	.....
Highways	2,709,000	....	....	5.0	135,450
Fencing and special improvements	799,000	....	....	2.0	15,980
Infiltration basins for utilization of surface flood waters	1,010,500	0.4	4,042	0.1	1,010
Reservoirs on salt-water estuaries	819,000	0.2	1,638	0.2	1,638
Conduits for diversion of water to streams and ponds. Lowering of ponds and necessary changes in lieu of damages	515,000	....	....	2.0	10,300
Temporary works, preliminary stage	15,000	....	....	....	.....
Engineering and contingencies, 20 per cent.	3,670,180	....	....	....	....
Total	**$22,021,100**	....	**$62,025**	....	**$365,373**
TRANSPORTATION WORKS					
Pumping-stations					
Buildings taxed outside City limits	$1,108,000	1.5	$16,620	2.0	$22,160
Equipment	1,693,500	....	....	3.5	59,273
Aqueduct lines					
Lands in Nassau and Queens	634,000	1.0	6,340	....	.....
Aqueduct, including earth work, masonry and earth embankment at wells	16,311,000	....	....	0.1	16,311
Special structures					
Above ground	79,000	1.0	790	2.0	1,580
Below ground	654,000	....	....	1.0	6,540
Fencing and special improvements, Queens and Nassau	327,000	....	....	2.0	6,540
Land damages, Queens and Nassau	153,000	....	....	....	.....
Engineering and contingencies, 20 per cent	4,191,900	....	....	....	.....
Total	**$25,151,400**	....	**$23,750**	....	**$112,404**

ANNUAL CHARGES

	Collecting Works	Transportation Works
Interest on total cost at 4 per cent	$880,800	$1,006,100
Sinking fund to pay bonds at end of 50 years, interest at 3 per cent. (0.887 per cent. of cost per year)	195,300	223,100
Taxes and special assessments	62,025	23,750
Extraordinary repairs and depreciation	365,370	112,400
Operating expenses and maintenance	557,970	601,800
Totals	**$2,061,470**	**$1,967,150**
Grand total		**$4,028,620**
Total amount of water supplied in million gallons, 365 x 250=		91,250
Cost of supply per million gallons		$44.15

BASIS OF ESTIMATES

The basis of these fixed charges and the allowances for depreciation and for maintenance and operation are presented in the following pages.

Interest

Interest on the bonds issued to cover the cost of these works has been estimated at 4.0 per cent. assuming that these would be issued for a term of 50 years. While recent issues have borne a higher rate, it is quite probable, with the passing of the present financial stringency, The City's bonds may be taken at a still lower rate of interest than here estimated.

Sinking Fund

An allowance has been made for annual payments for 50 years, which, with accrued interest, would amount to a sum sufficient at the end of this time to pay off the entire bond issue. The sinking fund requirements would be 0.887 per cent. each year on the entire cost of the works.

Taxes

Taxes are paid on the Ridgewood works in Nassau county on all lands and all buildings and other structures above ground. No payments are made on aqueducts, culverts, and other works below the ground surface.

Unlike the works of most surface-water supplies, the proposed Suffolk County works would not remove from taxation any large amount of property for reservoir purposes. Indeed, the betterments proposed on the right-of-way to be acquired would increase the value of taxable property in its vicinity. Annual payments of 1.0 per cent. upon the cost of all lands and small special structures on the aqueduct have been estimated, and 1.5 per cent. has been allowed on the cost of all buildings. To cover taxes and special assessments on the infiltration basins and reservoirs, 0.4 per cent. has been taken on the entire cost of the former and 0.2 per cent. on the latter.

Extraordinary Repairs and Depreciation

Liberal estimates on the depreciation of the works have been made in order that all structures may be maintained in perfect repair and all equipment replaced when worn out or inefficient.

LAND. No depreciation is figured on the land required. Its value would doubtless increase with the improvements proposed.

RESERVOIRS. An annual charge of 0.2 per cent. on the cost of the reservoirs or guard ponds is estimated to cover depreciation in embankments. An allowance of only 0.1 per cent. is made on the infiltration basins which would be in service for only a portion of the year.

MASONRY AQUEDUCTS. No depreciation should be charged on the generally low aqueduct embankments, as these would be cared for in the general maintenance and operation of the works. The masonry aqueducts would, however, require petty repairs now and then, and once in a while considerable repair work might be necessary, through settlements in their foundations caused by carelessly sinking wells. An allowance of 0.1 per cent. is made on the total cost including earth work.

STEEL-PIPE LINES. The life of steel pipes may be safely placed at 30 years, and the allowance for extraordinary repairs and depreciation would be 2.0 per cent.

SPECIAL MASONRY STRUCTURES. An allowance of 2.0 per cent. is made for the structures above ground that would be exposed to depreciation from floods, frost and other causes. Only 1.0 per cent. is figured in masonry structures below ground.

GATES, BLOW-OFFS AND SPECIAL IRON STRUCTURES. An allowance of 2.0 per cent. is made for these to cover renewals at the end of, say, 30 years.

WELLS. It is reasonably safe to assume that properly designed wells would have a life of 15 years. An allowance of 5.0 per cent. made on these estimates is therefore ample.

MASONRY WELL CHAMBERS. These, like special masonry structures, may be estimated at 1.0 per cent.

MOTORS AND ELECTRICAL EQUIPMENT IN PUMP-HOUSES. These are exposed to more moisture than is desirable for the best operation of electrical equipment, and allowance of 5.0 per cent. is made to cover extraordinary repairs and renewals.

PUMPS IN WELL. A satisfactory form of pump has not yet been found. Whatever type is adopted it is likely that a pump at a depth of 40 to 50 feet below the surface would suffer

much from inattention, and an allowance of 5.0 per cent. of cost is estimated to cover renewals of parts subject to wear.

ELECTRIC SUBSTATIONS. The buildings may be estimated at 2.0 per cent. and the equipment at 5.0 per cent.

ELECTRIC TRANSMISSION AND DISTRIBUTION. An allowance of 3.0 per cent. for concrete poles and wire of transmission lines has been made.

CENTRAL POWER-STATION. The charge for depreciation of the building is placed at 2.0 per cent. The generators should have a life of 20 years, and a depreciation of 3.5 per cent. is made. For the boilers 5.0 per cent. is allowed, and for the engines 3.0 per cent. An average for the entire equipment is placed at 3.5 per cent.

PUMPING-STATION AT RIDGEWOOD. An allowance of 2.5 per cent. is reasonable for the depreciation on the high-duty pumping-engines, and 5.0 per cent. may be allowed for the boilers. The average for the entire equipment would be 3.5 per cent.

PUMPING-STATION AT RIVERHEAD. This is not a large item, and the depreciation on the motors and pumps may be estimated at 5.0 per cent.

HIGHWAYS. While the force employed on the right-of-way should be able to keep the macadam roads in repair, they would very likely require reconstruction from time to time if they should be used for heavy motor traffic. An allowance of 5.0 per cent. is made.

FENCING AND SPECIAL IMPROVEMENTS. An allowance of 2.0 per cent. is made for extraordinary repairs due to breakage and rusting of the wire fencing proposed, and for renewals of parks and other improvements.

OPERATION AND MAINTENANCE

COLLECTING WORKS

The cost of operating the pumping system of the collecting works has already been computed in Appendix 6. In addition to the figures there estimated, a further annual charge of $1000 per mile of collecting works has been made for additional electricians, machinists and laborers, to make repairs on motors, pumps and wells, and maintain other portions of the collecting works. On the branch lines, only $500 per mile has been estimated because the equipment there would not be operated continuously.

The four infiltration basins can readily be cared for by the force employed along the aqueduct lines. An estimate of $3000 per year is made for salaries of attendants at each of the five reservoirs on the salt-water estuaries where locks would be built. The care of the embankments and slopes of these and the smaller reservoirs along the south shore would be left to the men similarly employed on the aqueduct line. The cost of maintenance of the water-levels in the private ponds is also included in the cost of operation of the collecting works.

TRANSPORTATION WORKS

Most of the cost of transportation is incurred at the pumping-stations at Brooklyn and Riverhead, which is given in Appendices 6 and 10. An estimate of $500 per year for each mile of aqueduct is included in the annual operating expenses of the transportation works to cover cleaning of aqueducts and care of special structures, and all necessary work on aqueduct embankments and right-of-way. The highways, fencing and other improvements would also be maintained by the men provided in this estimate.

COST OF WORKS FOR 150 MILLION GALLONS PER DAY

For comparison with the project here proposed for the complete development of the Suffolk County sources, another for only 150 million gallons per day has been estimated in order to learn if there would be any economy in first constructing an aqueduct of only 150 million gallons daily capacity, and at the end of, say, 20 years duplicating the first, when the entire yield of the Suffolk County watershed would be required.

EXTENT OF WORKS

The works for a supply of 150 million gallons per day need be constructed only as far as South Haven, which is the limit of the works in the second stage of the complete development of 250 million gallons per day. The first two stages and the preliminary stage would be identical in the two projects, excepting that, for the works providing only 150 million gallons daily, the aqueduct from Suffolk county to Brooklyn would have a nominal capacity only sufficient for this yield, and the main south shore aqueduct in Suffolk county would be proportionately smaller than that of the previous project.

The third and last stage of the works for 150 million gallons per day would include two branch lines (Melville and Connetquot) into the center of the island. These would be identical with those provided in the complete development.

The extent of these works completed at each stage is summarized below:

Stage	Average Supply for New York City Million Gallons Daily	Works Constructed at This Stage
Preliminary..	50	Construction of 10 miles of aqueduct and collecting works from Nassau County line to Bayshore. Temporary power-plant and 2 miles of main aqueduct from Suffolk county to Massapequa with connection to Ridgewood system
1...........	70	Completion of main aqueduct from Suffolk county to Brooklyn borough and pumping station near Ridgewood, with equipment for pumping 120 million gallons per day. Extension of aqueduct and collecting works in Suffolk county to Great River, 14.7 miles from Nassau County line, and construction of permanent power-station near Patchogue
2...........	150	Extension of aqueduct and collecting works from Great River to end of this development at South Haven, 29.5 miles from Nassau County line. Completion of pumping equipment at Ridgewood to handle 200 million gallons per day
3...........	150	Completion of this project by building the aqueduct and collecting works on the two branch lines into the center of the island to Melville and Lake Grove

Cost of Water from These Works

The cost of works and the supply from them is computed in Table 35 in the same manner as estimates for the project for 250 million gallons per day. The results are summarized in Table 2 with those of the complete development.

TEMPORARY WORKS IN SUFFOLK COUNTY

Estimates of cost have also been made on two projects for the temporary development of 50 and 100 million gallons per day, respectively, supposing that, at the expiration of 10 years, an abundant supply from the Catskill sources is available and that the works in Suffolk county could be disposed of.

In both of these temporary projects, it is assumed that the supply would be delivered to the Ridgewood system at Massapequa and pumped through the proposed extension of the 72-inch steel pipe to Brooklyn, as provided in the preliminary stage of the permanent works. For the project for 100 million gallons per day, the entire head from the pumps at Mas

TABLE 35

Estimates of Cost of Suffolk County Works and Total Annual Expenditures and Cost of Water Based Upon Fixed Charges and Operating Expenses. Project for Permanent Supply of 150 Million Gallons Daily. Preliminary Stage. Average Supply of 50 Million Gallons Daily

	Cost	Taxes		Extraordinary Repairs and Depreciation	
		Rate Per cent.	Amount	Rate Per cent.	Amount
COLLECTING WORKS					
Well system					
Wells	$63,600	....	....	5.0	$3,180
Pumps, motors, concrete chambers below ground, control and all connections	226,000	....	....	5.0	11,300
Transmission system substations					
Substation buildings	30,000	1.5	$450	2.0	600
Equipment	51,000	....	....	4.0	2,040
Line, poles, wire, etc	90,000	1.0	900	3.0	2,700
Telephones	3,000	1.0	30	3.0	90
Central power-station					
Buildings above ground	15,000	1.5	225	25.0	3,750
Equipment	235,000	....	....	3.5	8,225
Land for right-of-way, borrow-pits, spoil-banks and roads	1,027,000	1.0	10,270	....	.....
Land and water damages	500,000	....	....	....	.....
Highways	400,000	....	....	5.0	20,000
Fencing and special improvements	220,000	....	....	2.0	4,400
Infiltration basins for utilization of surface flood waters	276,500	0.4	1,106	0.1	277
Conduits for diversion of water to streams and ponds. Lowering of ponds and necessary changes in lieu of damages	165,000	....	....	2.0	3,300
Engineering and contingencies, 20 per cent	660,420	....	....	....	.....
Total	**$3,962,520**	....	**$12,981**	....	**$59,862**
TRANSPORTATION WORKS					
Pumping-stations: buildings taxed outside City limits	$5,000	1.5	$75	2.0	$100
Aqueduct lines					
Lands in Nassau and Queens	62,000	1.0	620	....	.....
Aqueduct, including earth work, masonry and earth embankment at wells	2,051,000	....	....	0.1	2,050
Special structures					
Above ground	5,000	1.0	50	2.0	100
Below ground	55,000	....	....	1.0	550
Fencing and special improvements, Queens and Nassau	38,000	....	....	2.0	760
Land damages, Queens and Nassau	15,000	....	....	....	....
Engineering and contingencies, 20 per cent	446,200	....	....	....	.....
Total	**$2,677,200**	....	**$745**	....	**$3,560**

ANNUAL CHARGES

	Collecting Works	Transportation Works
Interest on total cost at 4 per cent	$158,500	$107,080
Sinking fund to pay bonds at end of 50 years, interest at 3 per cent. (0.887 per cent. of cost per year)	35,100	23,750
Taxes and special assessments	13,000	750
Extraordinary repairs and depreciation	59,900	3,560
Operating expenses and maintenance	128,300	133,860
Totals	**$394,800**	**$269,000**
Grand total		**$663,800**
Total amount of water supplied in million gallons, 365 x 50 =		18,250
Cost of supply per million gallons		$36.37

No reservoirs for salt-water estuaries, no temporary works and no land outside of aqueduct right-of-way required for this stage.

TABLE 35 (*Continued*)

Estimates of Cost of Suffolk County Works and Total Annual Expenditures and Cost of Water Based Upon Fixed Charges and Operating Expenses. Project for Permanent Supply of 150 Million Gallons Daily. Stage 1. Average Supply of 70 Million Gallons Daily

	Cost	Taxes		Extraordinary Repairs and Depreciation	
		Rate Per cent.	Amount	Rate Per cent.	Amount
COLLECTING WORKS					
Well system					
Wells	$81,650	....	....	5.0	$4,083
Pumps, motors, concrete chambers below ground, control and all connections	334,00	....	....	5.0	16,700
Transmission system substations					
Land outside right-of-way	83,000	1.0	$830	....	.....
Substation buildings	42,000	1.5	630	2.0	840
Equipment	68,000	....	....	4.0	2,720
Line, poles, wire, etc	118,000	1.0	1,180	3.0	3,540
Telephones	4,200	1.0	42	3.0	126
Central power-station					
Land	10,000	1.0	100	....	.....
Buildings					
Above ground	524,000	1.5	7,860	2.0	10,480
Foundations	51,000	....	....	1.0	510
Equipment	258,000	....	....	3.5	9,030
Land for right-or-way, borrow-pits, spoil-banks and roads	1,819,000	1.0	18,190	....	.....
Land and water damages	735,000	....	....	....	.....
Highways	578,000	....	....	5.0	28,900
Fencing and special improvements	266,000	....	....	2.0	5,320
Infiltration basins for utilization of surface flood waters	276,500	0.4	1,106	0.1	277
Conduits for diversion of water to streams and ponds. Lowering of ponds and necessary changes in lieu of damages	200,000	....	....	2.0	4,000
Temporary works, preliminary stage	15,000	....	....	....	.....
Engineering and contingencies, 20 per cent	1,092,670	....	....	....	.....
Total	**$6,556,020**	....	**$29,938**	....	**$86,526**
TRANSPORTATION WORKS					
Pumping-stations					
Buildings taxed outside City limits	$694,000	1.5	$10,410	2.0	$13,880
Equipment	858,000	....	....	3.5	30,030
Aqueduct lines					
Lands in Nassau and Queens	634,000	1.0	6,340	....	.....
Aqueduct, including earth work, masonry and earth embankment at wells	7,448,000	....	....	0.1	7,448
Special structures					
Above ground	32,000	1.0	320	2.0	640
Below ground	413,000	....	....	1.0	4,130
Fencing and special improvements, Queens and Nassau	332,000	....	....	2.0	6,640
Land damages. Queens and Nassau	153,000	....	....	....	.....
Engineering and contingencies, 20 per cent	2,112,800	....	....	....	.....
Total	**$12,676,800**	....	**$17,070**	....	**$62,768**

ANNUAL CHARGES

	Collecting Works	Transportation Works
Interest on total cost at 4 per cent	$262,240	$507,070
Sinking fund to pay bonds at end of 50 years, interest at 3 per cent. (0.887 per cent. of cost per year)	58,150	112,440
Taxes and special assessments	29,940	17,070
Extraordinary repairs and depreciation	86,500	62,770
Operating expenses and maintenance	155,030	153,000
Totals	**$591,860**	**$852,350**
Grand total		**$1,444,210**
Total amount of water supplied in million gallons, 365 x 70 =		25,550
Cost of supply per million gallons		$56.53

No reservoirs for salt-water estuaries for this stage.

TABLE 35 (*Continued*)

ESTIMATES OF COST OF SUFFOLK COUNTY WORKS AND TOTAL ANNUAL EXPENDITURES AND COST OF WATER BASED UPON FIXED CHARGES AND OPERATING EXPENSES. PROJECT FOR PERMANENT SUPPLY OF 150 MILLION GALLONS DAILY. STAGE 2. AVERAGE SUPPLY OF 150 MILLION GALLONS DAILY

	Cost	Taxes		Extraordinary Repairs and Depreciation	
		Rate Per Cent.	Amount	Rate Per Cent.	Amount
COLLECTING WORKS					
Well system					
Wells	$223,180	....	....	5.0	$11,159
Buildings	5,000	1.5	$75	2.0	100
Pumps, motors, concrete chambers below ground, control and all connections	694,000	....	....	5.0	34,700
Transmission system substations					
Land outside right-of-way	83,000	1.0	830	....	.....
Substation buildings	84,000	1.5	1,260	2.0	1,680
Equipment	129,000	....	....	4.0	5,160
Line, poles, wire, etc.	173,000	1.0	1,730	3.0	5,190
Telephones	5,800	1.0	58	3.0	174
Central power-station					
Land	10,000	1.0	100	....	.....
Buildings					
Above ground	524,000	1.5	7,860	2.0	10,480
Foundations	51,000	....	....	1.0	510
Equipment	473,000	....	....	3.5	16,550
Land for right-of-way, borrow-pits, spoil-banks and roads	2,280,000	1.0	22,800	....	.....
Land and water damages	1,485,000	....	....	....	.....
Highways	1,209,000	....	....	5.0	60,450
Fencing and special improvements	438,000	....	....	2.0	8,760
Infiltration basins for utilization of surface flood waters	442,000	0.4	1,768	0.1	442
Reservoirs on salt-water estuaries	301,600	0.2	603	0.2	603
Conduits for diversion of water to streams and ponds. Lowering of ponds and necessary changes in lieu of damages	300,000	....	....	2.0	6,000
Temporary works, preliminary stage	15,000	....	....	....	.....
Engineering and contingencies, 20 per cent.	1,787,116	....	....	....	.....
Total	**$10,712,696**	....	**$37,084**	....	**$161,958**
TRANSPORTATION WORKS					
Pumping-stations					
Buildings taxed outside City limits	$694,000	1.5	$10,410	2.0	$13,880
Equipment	1,248,000	....	....	....	.....
Aqueduct lines					
Lands in Nassau and Queens	634,000	1.0	6,340	....	.....
Aqueduct, including earth work, masonry and earth embankment at wells	9,669,000	....	....	0.1	9,669
Special structures					
Above ground	46,000	1.0	460	2.0	920
Below ground	479,000	....	....	1.0	4,790
Fencing and special improvements, Queens and Nassau	332,000	....	....	2.0	6,640
Land damages, Queens and Nassau	153,000	....	....	....	.....
Engineering and contingencies, 20 per cent.	2,651,000	....	....	....	.....
Total	**$15,906,000**	....	**$17,210**	....	**$35,899**

ANNUAL CHARGES

	Collecting Works	Transportation Works
Interest on total cost at 4 per cent.	$428,910	$636,240
Sinking fund to pay bonds at end of 50 years, interest at 3 per cent. (0.887 per cent. of cost per year)	95,000	141,100
Taxes and special assessments	37,080	17,210
Extraordinary repairs and depreciation	161,960	35,900
Operating expenses and maintenance	277,250	355,000
Totals	**$1,000,200**	**$1,185,450**
Grand total		**$2,185,650**
Total amount of water supplied in million gallons, 365 x 150 =		54,750
Cost of supply per million gallons		$39.92

TABLE 35 (*Concluded*)

Estimates of Cost of Suffolk County Works and Total Annual Expenditures and Cost of Water Based Upon Fixed Charges and Operating Expenses. Project for Permanent Supply of 150 Million Gallons Daily. Stage 3. Average Supply of 150 Million Gallons Daily

	Cost	Taxes: Rate Per Cent.	Taxes: Amount	Extraordinary Repairs and Depreciation: Rate Per Cent.	Extraordinary Repairs and Depreciation: Amount
COLLECTING WORKS					
Well system					
Wells	$463,460	....	....	5.0	$23,173
Buildings	5,000	1.5	$75	2.0	100
Pumps, motors, concrete chambers below ground, control and all connections	1,087,000	....	....	5.0	54,350
Transmission system substations					
Land outside right-of-way	83,000	1.0	830	....	.....
Substation buildings	106,000	1.5	1,590	2.0	2,120
Equipment	174,000	....	....	4.0	6,960
Line, poles, wire, etc.	201,000	1.0	2,010	3.0	6,030
Telephones	8,000	1.0	80	3.0	240
Central power-station					
Land	10,000	1.0	100	....	.....
Buildings above ground	575,000	1.5	8,625	2.0	11,500
Equipment	581,000	....	....	3.5	20,335
Land for right-of-way, borrow-pits, spoil-banks and roads	2,836,000	1.0	28,360	....	.....
Land and water damages	2,060,000	....	....	....	.....
Highways	1,599,000	....	....	5.0	79,950
Fencing and special improvements	539,000	....	....	2.0	10,780
Infiltration basins for utilization of surface flood waters	520,500	0.4	2,082	0.1	521
Reservoirs on salt-water estuaries	301,600	0.2	603	0.2	603
Conduits for diversion of water to streams and ponds. Lowering of ponds and necessary changes in lieu of damages	300,000	....	....	2.0	6,000
Temporary works, preliminary stage	15,000	....	....	....	.....
Engineering and contingencies, 20 per cent.	2,292,912	....	....	....	.....
Total	**$13,757,472**	....	**$44,355**	....	**$222,662**
TRANSPORTATION WORKS					
Pumping-stations					
Buildings taxed outside City limits	$694,000	1.5	$10,410	2.0	$13,880
Equipment	1,248,000	....	....	3.5	43,680
Aqueduct lines					
Lands in Nassau and Queens	634,000	1.0	6,340	....	.....
Aqueduct, including earth work, masonry and earth embankment at wells	10,396,000	....	....	0.1	10,396
Special structures					
Above ground	48,000	1.0	480	2.0	960
Below ground	501,000	....	....	1.0	5,010
Fencing and special improvements, Queens and Nassau	332,000	....	....	2.0	6,640
Land damages, Queens and Nassau	153,000	....	....	....	.....
Engineering and contingencies, 20 per cent.	2,801,200	....	....	....	.....
Total	**$16,807,200**	....	**$17,230**	....	**$80,566**

ANNUAL CHARGES

	Collecting Works	Transportation Works
Interest on total cost at 4 per cent.	$550,300	$672,300
Sinking fund to pay bonds at end of 50 years, interest at 3 per cent. (0.887 per cent. of cost per year)	122,030	149,100
Taxes and special assessments	44,360	17,230
Extraordinary repairs and depreciation	222,660	80,600
Operating expenses and maintenance	302,550	358,600
Totals	**$1,241,900**	**$1,277,830**
Grand total		**$2,519,730**
Total amount of water supplied in million gallons, 365 x 150		54,750
Cost of supply per million gallons		$46.02

sapequa would be used up in friction losses in the 72-inch pipe, and a temporary station provided in these estimates would be erected at the westerly end of this pipe-line, near Ridgewood, to deliver the supply directly into the distributing mains.

PROJECT FOR SUPPLY OF 50 MILLION GALLONS DAILY

Driven-well stations of the same design as those of the Ridgewood system would be constructed at intervals of a mile on the location proposed for the permanent works. A strip of land 1000 feet wide would be acquired at each station for a length of 500 feet east or west of the outer units of the well system. Between the stations, a right-of-way of 100 feet would be purchased for the aqueduct. The aqueduct would be of masonry, of the cut-and-cover type, of 50 million gallons daily capacity, and would carry the supply entirely by gravity to the proposed pumping-station at Massapequa. The entire works would be built in the cheapest way possible, and no highways or other improvements would be considered.

The cost of these works, and an estimate of the fixed charges and operating expenses is shown in Table 36, and the expense to the consumer of each million gallons delivered into the City mains is found, as in the other projects. The annual expenditure includes the cost of pumping through the 72-inch pipe-line but not the fixed charges on the works of the Ridgewood system. A charge for depreciation has been made sufficient to cover the entire cost of the works, at the expiration of the period of 10 years, after which the equipment would be disposed of and the lands sold.

PROJECT FOR SUPPLY OF 100 MILLION GALLONS DAILY

The project for a temporary supply of 100 million gallons per day would be similar to the above. The masonry aqueduct would, however, have a capacity of 100 million gallons per day, and would extend from the Nassau-Suffolk County line, 20 miles easterly as far as Sayville, and driven-well stations, one mile apart, would be constructed to the end of the line.

The annual charges are computed in Table 37, in the same manner as on the works for a temporary supply of 50 million gallons per day. The station erected in Brooklyn to pump the supply into the distribution system would be charged off, with the works in Suffolk county, at the end of 10 years.

TABLE 36

Estimates of Cost of Suffolk County Works and Total Annual Expenditures and Cost of Water Based Upon Fixed Charges and Operating Expenses. Project for Temporary Development. Average Supply of 50 Million Gallons Daily for 10 Years

	Cost	Taxes: Rate Per Cent.	Taxes: Amount
COLLECTING WORKS			
Well system			
Wells	$100,000	....	......
Buildings	150,000	1.5	$2,250
Pumps, motors, concrete chambers below ground, control and all connections	110,000	....	......
Land for right-of-way, borrow-pits, spoil-banks and roads	441,800	1.0	4,418
Land and water damages	500,000	....	......
Fencing and special improvements	94,000	....	......
Engineering and contingencies, 20 per cent	279,160	....	......
Total	**$1,674,960**	....	**$6,668**
TRANSPORTATION WORKS			
Aqueduct lines			
Lands in Nassau and Suffolk counties	$85,744	1.0	$857
Aqueduct, including earth work and masonry	820,872	....	......
Special structures			
Above ground	4,500	1.0	45
Below ground	80,500	....	......
Fencing and improvements, Nassau and Suffolk counties	44,850	....	......
Land damages, Nassau and Suffolk counties	60,000	....	......
Engineering and contingencies, 20 per cent	219,293	....	......
Total	**$1,315,759**	....	**$902**

ANNUAL CHARGES

	Collecting Works	Transportation Works
Interest on total cost at 4 per cent	$66,998	$52,630
Sinking fund to pay bonds (exclusive of land) at end of 10 years, interest at 3 per cent. (8.72 per cent. of cost per year)	99,827	105,762
Taxes and special assessments	6,668	902
Operating expenses and maintenance	168,850	133,000
Totals	**$342,343**	**$292,294**
Grand total		**$634,637**
Total amount of water supplied in million gallons, 365 x 50 =		18,250
Cost of supply per million gallons		$34.77

TABLE 37

Estimates of Cost of Suffolk County Works and Total Annual Expenditures and Cost of Water Based Upon Fixed Charges and Operating Expenses. Project for Temporary Development. Average Supply of 100 Million Gallons Daily for 10 Years

	Cost	Taxes Rate Per Cent.	Taxes Amount
COLLECTING WORKS			
Well system			
Wells	$200,000	....	......
Buildings	300,000	1.5	$4,500
Pumps, motors, concrete chambers below ground, control and all connections	220,000	....	......
Land for right-of-way, borrow-pits, spoil-banks and roads	645,450	1.0	6,455
Land and water damages	1,000,000	....	......
Fencing and special structures	168,000	....	......
Engineering and contingencies, 20 per cent	506,690	....	......
Total	**$3,040,140**	....	**$10,955**
TRANSPORTATION WORKS			
Pumping-stations			
Buildings taxed outside City limits	$100,000	1.5	$1,500
Temporary building at Ridgewood	220,000	....	......
Equipment			
Massapequa	140,000	....	......
Ridgewood	227,000	....	......
Aqueduct lines			
Lands in Nassau and Suffolk counties	130,211	1.0	1,302
Aqueduct, including earth work and masonry	1,821,715	....	......
Connections at Ridgewood	50,000	....	......
Special structures			
Above ground	4,500	1.0	45
Below ground	191,965	....	......
Fencing and special improvements, Nassau and Suffolk counties	85,000	....	......
Land damages, Nassau and Suffolk counties	110,000	....	......
Engineering and contingencies, 20 per cent	616,078	....	......
Total	**$3,696,469**	....	**$2,847**

ANNUAL CHARGES

	Collecting Works	Transportation Works
Interest on total cost at 4 per cent	$121,606	$147,853
Sinking fund to pay bonds (exclusive of land) at end of 10 years, interest at 3 per cent. (8.72 per cent. of cost per year)	197,560	308,701
Taxes and special assessments	10,955	2,847
Operating expenses and maintenance	334,700	522,374
Totals	**$664,821**	**$981,775**
Grand total		**$1,646,596**
Total amount of water supplied in million gallons, 365 x 100 =		36,500
Cost of supply per million gallons		$45.12

APPENDIX 12

EFFECT OF DIVERSION OF SUFFOLK COUNTY GROUND-WATERS UPON THE OYSTER INDUSTRY IN THE GREAT SOUTH BAY *

BY GEORGE C. WHIPPLE, CONSULTING ENGINEER

INTRODUCTION

In order to safeguard one of the important Long Island industries, an extended investigation was made to determine whether the diversion of a certain amount of ground-water for the supply of Brooklyn would so reduce the fresh-water accessions of the Great South bay as to injuriously affect the value of that body of water as a place for growing oysters. It has been long held by oyster growers that fresh water finding its way into an arm of the sea is beneficial to the cultivation of oysters, and oyster experts recognize that there are certain limits of salinity, or brackishness, within which oysters thrive best. It is believed by the Long Island oystermen that the Great South bay owes its successful oyster crops, in part at least, to the accessions of fresh water which the bay receives from the streams on the southerly slopes of Suffolk county and from the ground-water that enters the bay in the form of springs over the bottom, and the fear has arisen that the diversion of a part of the ground-water may so reduce the available supply of fresh water that the oyster crop will be injured. This fear is a natural one, as such a diversion will make the water of the bay somewhat more saline than it now is, but the observations and calculations that have been made indicate that the fear of damage to the oyster industry, broadly considered, is groundless. A few oyster-beds that now enjoy a favorable specific gravity of the water may have that specific gravity increased beyond the favorable point, but on the other hand, large areas where the specific gravity is not now favorable would be improved. Studies have further shown that by far the largest number of beds would not be materially affected either one way or the other.

*This report submitted by Mr. Whipple's associate, Mr. Allen Hazen, Consulting Engineer

The various conditions that influence the growth of oysters and give them their salable qualities are very complicated and involve many other factors than salinity. Hence, in order to arrive at a logical conclusion it became necessary to carry on a series of studies covering a wide range and to take into account not only salinity but questions of food supply, depth of water, character of the bottom, tides, currents, etc. Incidentally, various sanitary problems involved in the production and marketing of the oysters from this locality were considered.

The investigation was carried on in accordance with instructions received from Mr. J. Waldo Smith, Chief Engineer, in his letter to my partner, Mr. Allen Hazen, dated November 4, 1907. The work was begun in November, 1907, and continued for about two months. The field work was arranged for and conducted under the direction of Mr. Walter E. Spear, Division Engineer in charge of the investigation of the Long Island sources. A preliminary report of this investigation was presented on February 25, 1908. Supplementary studies were made in the field during the months of July, September, October and November, 1908. These were carried on under my direction by Milton W. Davenport, who acted as chemist and biologist with headquarters at Babylon, Long Island, and who worked in cooperation with Mr. Walter E. Spear, Division Engineer. A final report was made on April 20, 1909.

In 1908 a laboratory was arranged in a small building in the rear of the field office of the New York Board of Water Supply and equipped with apparatus for making determinations of chlorine, color, turbidity, microscopic organisms, etc. The routine work consisted of collecting and analyzing samples of water from various parts of the bay, making observations of currents, tides, etc., and studying by experiment the influences controlling the growth of the microscopic organisms which furnish the food supply to the oysters, with particular reference to the effect of salinity. Studies were also made of the oysters themselves, many specimens being gathered and dissected. Visits were made to many of the oyster houses and sanitary inspections were made of the conditions along the shore. For comparison, studies were also carried on in Jamaica bay, Moriches bay, Shinnecock bay, and other places on Long Island where oysters are grown. The

literature of the subject was investigated and interviews held with various oyster growers, marketmen, state officials and experts of the U. S. Bureau of Fisheries. The results of these researches were set forth at length in the two reports above referred to. The following is an abridgment of these reports.

THE OYSTER

The oysters found on the Atlantic Coast belong to a single species,—*ostrea virginica*. This species is different from the European oyster and from those found on the Pacific Coast.

The oyster has two parts—the shell, and the living organism.

The Shell

The shell of the oyster is a calcareous secretion which serves as a protective covering. Its two parts are joined by a hinge, one of the shells being flat, the other convex. The latter forms the "bowl" in which the organism dwells, while the flat side, or top, forms a movable lid. The shell is composed chiefly of calcium carbonate, as shown by the following analysis of a 3-year old oyster received from Babylon, Long Island, which was 3.5 inches long, 2.5 inches wide and 1.3 inches deep.

Calcium carbonate ($CaCO_3$)	93.98 per cent.
Magnesium carbonate ($MgCO_3$)	1.20 per cent.
Iron (Fe_2O_3)	0.26 per cent.
Alumina (Al_2O_3)	0.00 per cent.
Undetermined	4.56 per cent.
	100.00 per cent.

The shell is arranged so that it can be opened or shut at will by a powerful adductor muscle in the center of the oyster. The muscle has to be cut before the shell can be opened.

The shape of the shell depends upon several things, chiefly on the number of oysters spread over a given area and the amount of mud on the bottom. The size depends upon the age and rate of growth. The latter is largely a function of the available food supply.

The Organism

In opening an oyster it is held with the small end outwards and the flat side upwards. The knife is inserted at a vulnerable point on the right near the small end. After the thin blade has entered the shell it is passed inward across the oyster, close to the top, so as to sever the adductor muscle, after which, with a slight turn of the knife, the two shells can be parted and the flat side removed, leaving the oyster lying in the deep bowl.

Viewed in this position, the different parts of the anatomy are conspicuous, namely, the adductor muscle in the middle of the organism, the mantle and gills around the edge of the shell, the dark-colored liver surrounding the stomach, the long intestines and the colorless heart, which, in the case of a freshly opened oyster, may be seen to beat at intervals of 15 to 30 seconds.

The oyster is propagated by means of eggs fertilized in the water after leaving the shell. These gradually increase in size but float in the water until a thin shell begins to form. At this stage they are called " spat " and, being heavy, tend to sink in the water. If they fall upon mud they are likely to be choked and if they settle on sand they are likely to be covered or broken up by the moving particles. If, however, they settle on shells or rocky beds, or become attached to twigs or other hard substances, they continue to grow and from that time on never leave the place where they become attached. Oyster growers are in the habit of covering the beds with clean shells for the reception of this spat.

Conditions Affecting Growth

TEMPERATURE. Oysters live in waters of widely varying temperature, from 32° to 90° F. In the vicinity of Long Island the water temperature in the summer seldom rises above 75°, while from May 1 to November 1 it seldom falls below 60°. Temperature has more effect on the spawning of the oyster than upon the growth of the adults. The temperature limits for spawning are about 65° to 80° F. Sudden changes of temperature are unfavorable.

SPECIFIC GRAVITY. The specific gravity of fresh water is 1.000; the specific gravity of sea-water is about 1.025. The specific gravity varies with the salinity of the water. Oysters

are said to thrive best when the density is between 1.011 and 1.022. They seldom live in water where the specific gravity falls below 1.007 for any considerable period of time. The range of specific gravities over the present oyster-beds in the Great South bay is from 1.013 to 1.020. Density affects the spawning of the oyster more than the adults. Spawning takes place more readily in waters of comparatively low density. Sudden changes in density are unfavorable.

CHARACTER OF THE BOTTOM. Muddy bottoms are unfavorable to the growth of oysters and are especially deleterious to the young fry. On the other hand, muddy bottoms near oyster-beds are advantageous to adult oysters, as the amount of food supply is more likely to be plentiful. Muddy bottoms tend to produce oysters of long and irregular shape.

CURRENTS. Oysters grow best in moving waters, as the organisms are sedentary and require their food to be brought to them. Moving waters also facilitate the fertilization of the eggs. Currents are deemed satisfactory if the velocities exceed ¼ mile per hour. Heavy seas may cause damage by depositing mud, sand and other debris upon the beds.

DEPTH OF WATER. The depth of water seems to influence the growth of oysters but little, as they are found growing anywhere from 0 to 90 feet below the surface. In most localities the depth of water over the beds is from 5 to 25 feet. Depth affects the convenience of harvesting and the care of the beds more than it does oyster growth.

FOOD SUPPLY. The food supply of oysters consist of microscopic organisms that float in the water and that are sometimes collectively referred to as "plankton." By far the larger part of the food supply consists of diatoms. These microscopic plants have a silicious shell wall and are heavier than water. They are, however, found at all depths and their vertical distribution is controlled chiefly by the wind. Generally speaking, the microscopic organisms are more abundant in warm weather than in cold weather. Oysters fatten most rapidly in the autumn after the spawning season. The fertility of oyster feeding grounds depends upon the number of diatoms in the water. This matter has been studied carefully by the experts of the U. S. Department of Fisheries and it has been found that the condition of the oyster is largely dependent on the abundance of the supply of diatoms. Many studies

have been made to ascertain the rate at which oysters feed, but no definite conclusions have yet been reached. It is said that the amount of water strained by an oyster in its search for food amounts to several gallons per day.

DENSITY OF GROWTH. Overcrowding produces ill-shaped oysters. To prevent this it is customary to limit the number of oysters sown on the Long Island beds to about 300 bushels per acre, that is, to about 60 oysters per square yard, which allows 21 square inches of space per oyster.

ENEMIES OF THE OYSTER. Young oyster fry are destroyed in enormous numbers by molluscs and fishes and are even consumed by adult oysters. Sponges, worms and various hydroida use them as food. The young oyster spat are often smothered by mussels, lingulas, sponges, barnacles, and tube-building worms, as well as by various kinds of seaweed. Among the more active enemies of the adult oyster are the starfish, the drumfish, drills, boring sponges, and periwinkles. Of these the starfish is the worst.

Commercial Aspects

The best oysters are round in shape and have a deep bowl. with the shell full of meat and the flesh firm and light colored Dark gray, watery oysters are not considered first-class. Taste depends pārtly upon saltness and partly upon the oyster itself.

Oysters are sold in two ways, in the shell and in bulk. The shell oysters are graded in size according to use. The shucked oysters are largely used for long distance shipments.

Oysters in the shell are sometimes floated, that is, placed for a time in water fresher than that in which they grew before marketing. This is partly to freshen them, partly to increase their size and partly to improve their keeping qualities. When conducted in clean water it is not very objectionable, but when the water is contaminated with sewage, as it often is, the hygienic quality of the oyster is threatened. This practice is to a considerable extent going out of use.

Quality of the Oyster Sold to the New York Market

In order to obtain some idea of the quality of the different oysters sold in the New York markets, samples were purchased during November, 1907, from various dealers and examined

as to their general condition and as to the presence of objectionable bacteria. Out of 13 different lots purchased, eight contained at least one oyster that gave a positive test for B. coli, while five lots failed to show this indication of contamination. Of the three lots said to come from Cape Cod, two gave no indications of contamination, while the third one did. The oysters said to come from Connecticut gave positive tests for B. coli, as did those from New Jersey, from Lynn Haven and Jamaica bay. Of five lots from Rockaway, three gave positive tests for B. coli. Considering all the lots together, about 35 per cent. of the oysters showed the presence of B. coli in one cubic centimeter of the liquor found in the shells. This is a somewhat smaller per cent. than has been found by those who have carried on similar investigations in this City.

GREAT SOUTH BAY

General Description

The Great South bay is one of a series of land-locked bodies of brackish water that extends along the southern shore of Long Island. Named in their order, from west to east, these bays are, Jamaica bay, Hempstead bay, South Oyster bay, Great South bay, Moriches bay, Shinnecock bay. They are all formed by a ridge of sand that lies at an average distance of about three or four miles from the main shore of the island and parallel to it. This ridge forms a series of beaches broken at intervals by inlets. The principal beaches are known as Coney Island; Rockaway beach, enclosing Jamaica bay; Long beach, enclosing Hempstead bay; Jones beach; Oak Island beach; Fire island and Great South beach, enclosing the Great South bay; West Hempstead beach, enclosing Moriches bay, etc. The sand ridge is comparatively narrow, its width often being not over ¼ mile and seldom over a mile. The elevation is seldom over 50 feet and in many places it is less. The inlets to the bay are small and not permanent. Within comparatively recent years, old inlets have been almost closed and new ones opened. The Fire Island inlet is constantly making westward. Less than a century ago the end of the bar was in the vicinity of the present lighthouse. To-day it is nearly two miles west of the lighthouse and there are indications that this natural process is still going on.

Jamaica bay is a separate one, but the other bays are con-

nected together. The Great South bay is connected with Moriches bay on the east by a narrow channel and on the west with a series of bays, much broken up with islands. Moriches bay is connected with Shinnecock bay and the latter is connected with Peconic bay by means of the Peconic canal, and occasionally with the ocean by means of artificial channels cut through the bar. These channels fill up with sand after a time. The principal inlet of the Great South bay is the Fire Island inlet and the extreme eastern and western portions of the bay are more or less stagnant so far as tidal flow is concerned.

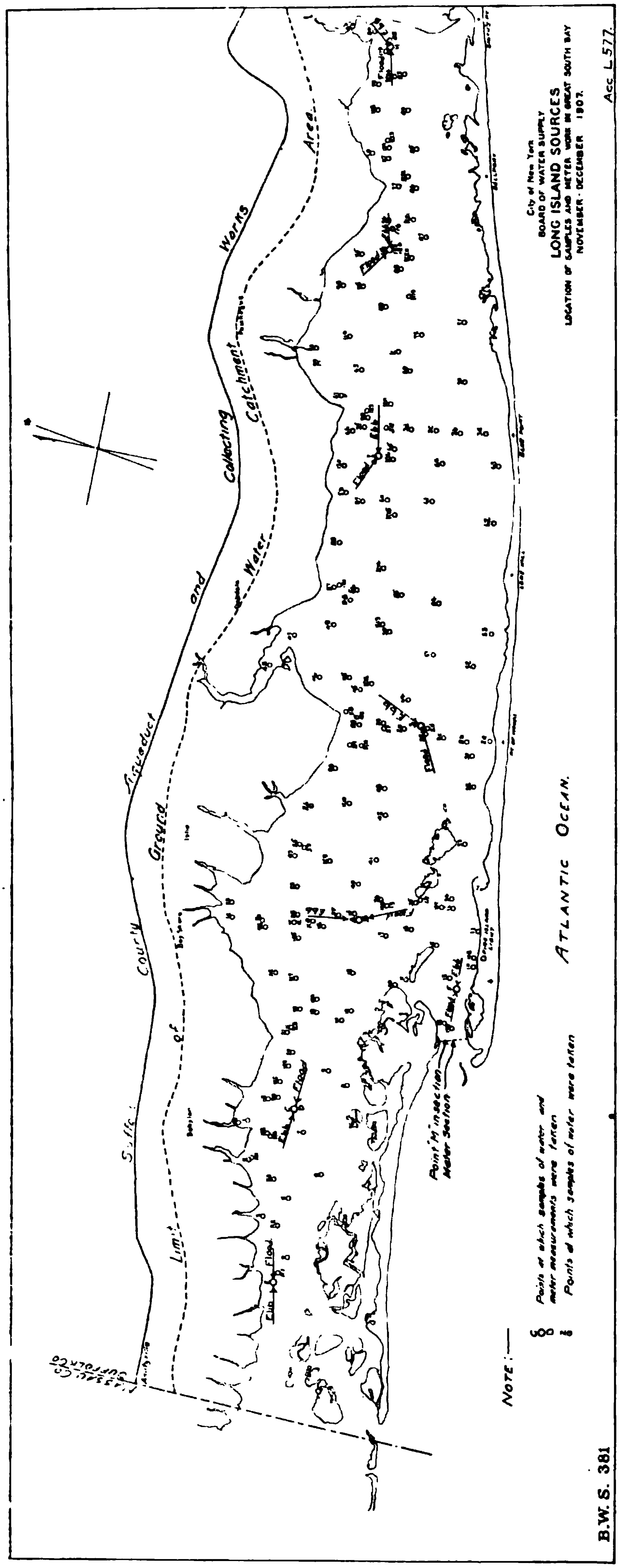
The Great South Bay is about 25 miles long, from a point a few miles west of Babylon to a point a few miles east of Bellport. The width of the bay varies from 1½ to 5 miles and averages about three miles. The south shore formed by the sand of the bar is almost straight, but the northern shore is broken into a series of bays, several of which are estuaries of streams.

The main current of sea-water enters the bay at Fire Island inlet through a channel ¾ mile wide, extending in a general easterly direction between Sexton island and Fire island. Near Fire Island light the channel divides into the west channel that extends northward and the east channel that follows the line of the beach easterly to the Point of Desire. Both of these channels are narrow and the depth of the water is between 15 and 25 feet.

The bay as a whole is comparatively shallow. The deepest portions extend from Bayshore to Patchogue and lie from ¼ mile to 2 miles from the main shore. For the most part the regions within 1½ miles of the sandbar, which forms the south shore, are shallow, although broken here and there near the inlet with channels. The easterly and westerly ends of the bay are also shallow. In the deeper portions of the bay the depths run from 6 to 12 feet; over the flats they run from one to six feet.

For the most part the floor of the bay is hard and sticky, but in some places, especially near the east end, the bottom is soft. Over the oyster-beds the character of the bottom has been materially altered by its continuous use for oyster culture. In some regions areas of mud and shell bottoms are closely alternated.

The watershed tributary to the bay has an area of about


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
LOCATION OF SAMPLES AND METER WORK IN GREAT SOUTH BAY
NOVEMBER - DECEMBER 1907.
Acc L577.
Suffolk County Aqueduct and Collecting Works
Limit of Ground Water Catchment Area
ATLANTIC OCEAN.
Point 'M' in section
Meter Section
NOTE:—
Points at which samples of water and meter measurements were taken
Points at which samples of water were taken
Nassau Co
Suffolk Co
B.W.S. 381

252 square miles. It extends the entire length of the bay, but is deeper on the eastern half where the streams are longer and where the amount of fresh water entering is larger. The narrowest portion of the watershed is opposite Bayshore. The rainfall over the watershed averages about 45 inches per year, and the amount of water reaching the bay, including both surface and underground water, has been estimated to be about 1.2 million gallons per square mile per day. For a total drainage area of 252 square miles this amounts to about 300 million gallons per day. To this must be added the rain which falls on the bay, that is, 45 inches over 90 square miles, or about 194 million gallons per day. Hence the bay receives on an average 494 million gallons of fresh water daily. Of course this quantity varies greatly according to the rainfall, the figures given being mere averages.

The surface-water enters at the north side. The groundwater enters partly at the north side and partly at other points in the bay, possibly in the form of springs. On account of the greater amount of fresh water entering at the north side, the water is less saline there than at points on the south side directly opposite. This distribution, however, is due partly to the disturbing effects of currents and the shallow areas near the shore.

The following is a summary of various data relating to the Great South bay:

Length	25 miles
Width	1.5 to 5 miles
Area	90 square miles
Depth of water in entry channels	15 to 35 feet
Depth of water over the flats	1 to 6 feet
Average depth of the bay at low water	4.25 feet
Approximate range of tides	1.5 feet
Volume of water in the bay at low tide	105,000 million gallons
Area over which the depth at low tide is less than 6 feet	51 square miles (57 per cent.)
Area over which the depth at low tide is more than 6 feet	39 square miles (43 per cent.)

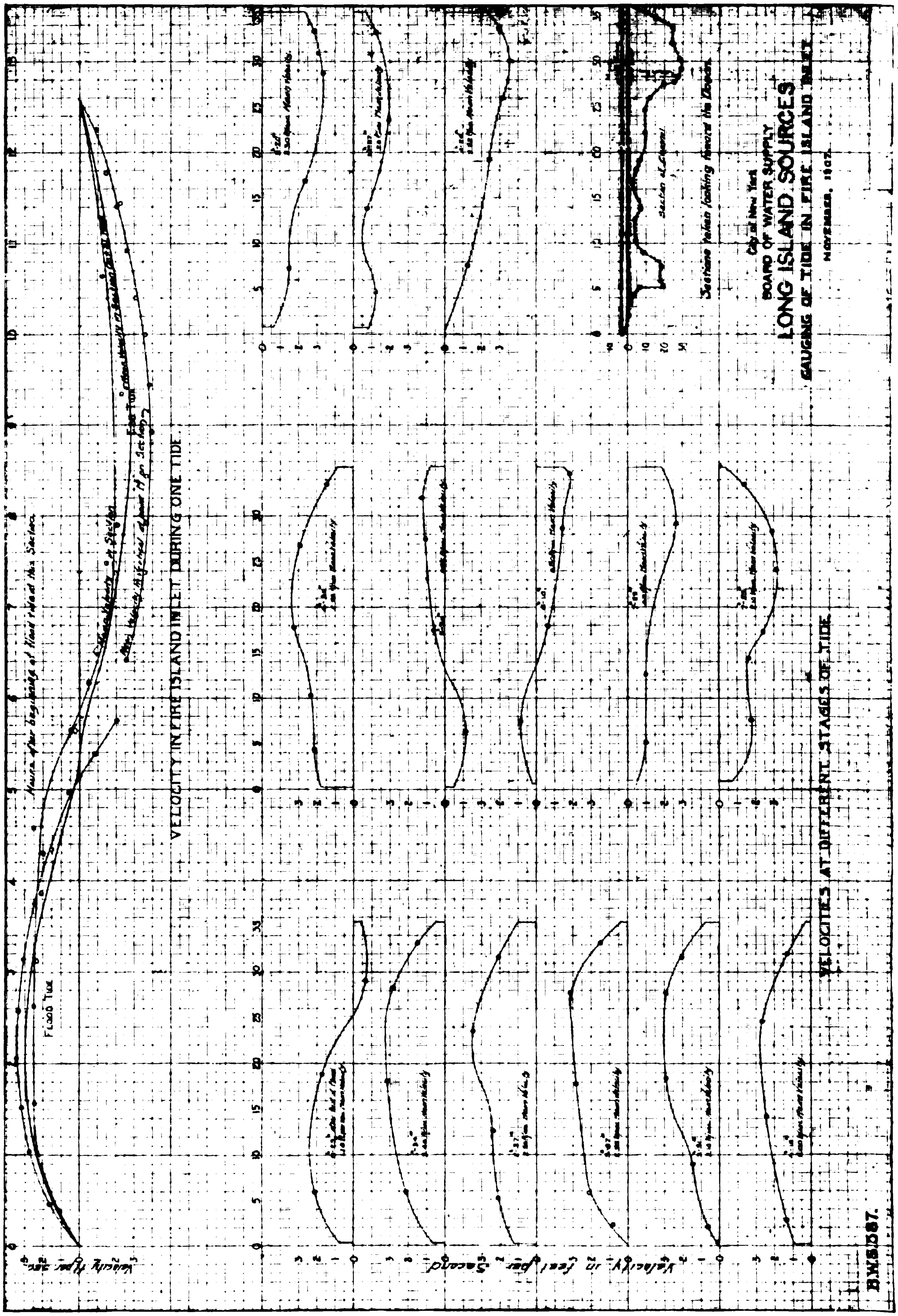
Drainage area tributary to the bay	252 square miles
Population per square mile on this drainage area	100
Rainfall on watershed, inches per annum	45
Estimated average flow of fresh water from watershed into bay, including surface and ground-water in gallons per day per square mile	1,200,000
Estimated average flow of fresh water from watershed into bay in million gallons per day	300
Estimated rainfall over bay, expressed as average daily flow in million gallons	194
Estimated total flow of fresh water into bay in million gallons daily	494

Tides and Currents

Fire Island inlet is comparatively narrow, averaging less than ¾ mile in width. Its length is about two miles. At Station F in the inlet (see Sheet 113, Acc. L 577), where current observations were made, the width is 3600 feet and the maximum depth, 30 feet. At this section there are 2 deep channels separated by comparatively shallow water. The north channel is 800 feet wide and 25 feet deep, and the south channel 400 feet wide and 20 feet deep. Between the channels for a length of 1800 feet the depth varies from 3 feet to 10 feet.

On October 21, 1907, a series of gagings was made at Station F in the Fire Island inlet, the results of which are shown on Sheet 114, Acc. L 579. On this date the total range of the tide at the inlet was found to be 3.3 feet, while at the same time it was 1.0 foot at Babylon and 0.9 foot at Patchogue. The high and low water on this date occurred as shown by the following figures:

SHEET 114


VELOCITY IN FIRE ISLAND INLET DURING ONE TIDE
Hours after beginning of Flood Tide at this Section
FLOOD TIDE
EBB TIDE
Velocity in feet per Second
Section of Channel
Sections taken looking toward the Ocean
VELOCITIES AT DIFFERENT STAGES OF TIDE
City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
GAUGING OF TIDE IN FIRE ISLAND INLET
NOVEMBER, 1907.
B.W.S.587.

HIGH AND LOW WATER, OCTOBER 21, 1907

STATION	TIME—LOW WATER	TIME—HIGH WATER	REMARKS
Fire Island, Inlet dock...	1.30 P.M. +.70	7.15 P.M. + .40	From scale readings
Babylon.......	4.50 P.M. +.09	10.00 P.M. +1.18	" recording tide gage
Patchogue.....	6.00 P.M. +.70	11.00 A.M. +1.60	" scale readings

Computations made from these gagings showed that 1954 million cubic feet of water entered the bay on the flood tide and 1948 million cubic feet left the bay on the ebb tide.

On December 7, 1907, a second series of gage readings was made at Station F in Fire Island inlet, the results of which are shown in the upper diagram on Sheet 117, Acc. L 578. On this date the tidal range was from 1.4 feet below mean tide level to 1.9 feet above it,—that is, 3.3 feet. Flood tide began about 3.2 hours after low water, and continued for about 5.5 hours. The duration of the ebb tide was about 7 hours, but this was not accurately determined.

At low water the mean velocity of the outgoing water at the point " M " in the deep channel at the meter station (see location on Sheet 114, Acc. L 579) was 3.8 feet per second. Between low water and slack tide the velocity of the outward current gradually decreased until it became zero a few minutes after mean tide level had been reached. The current then set inwards, and increased rapidly. One hour after slack tide it was between 2.5 and 3.0 feet per second. The maximum inward velocity was reached at high tide and was about 3.4 feet per second. At slack tide after high water the velocity again became zero, and the outward current began to increase rapidly. At low tide a velocity of 3.85 feet per second was reached.

Current measurements were made on December 7 at other points than " M " in the cross-section of the inlet at Station F. The results have been shown on a series of diagrams not here reproduced. The curves indicate, as did those worked up from the measurements of October 21, 1907 (See Sheet 114, Acc. L 579) that the velocities were greatest in the deep channel. Taking the section as a whole the duration of flood tide was found to be 5.75 hours, and ebb tide 6.80 hours. The mean velocity of the flood tide was 2.07 feet per second, and of the ebb tide 1.42 feet per second. If the cross-section of the section is taken as 47,300 square feet, then the volume of

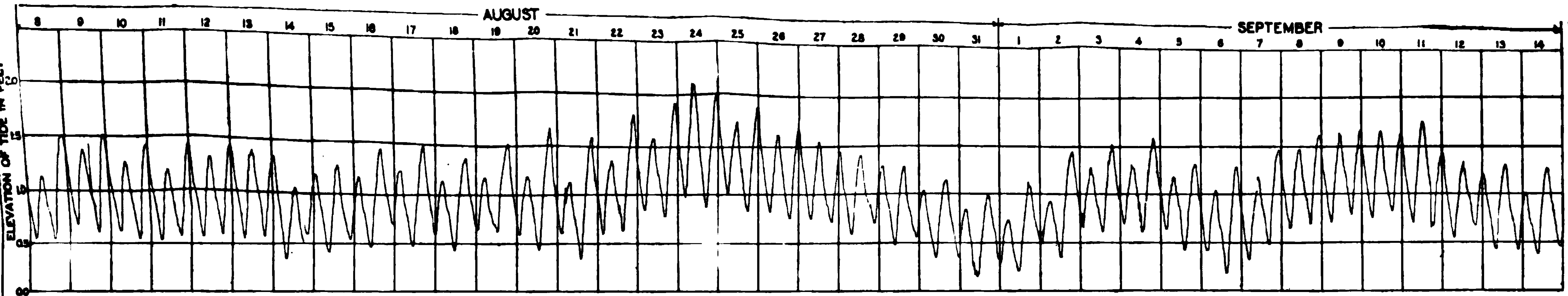
water that entered the bay on the flood tide was 2020 million cubic feet and the volume that left the ebb tide was 1640 million cubic feet. The difference amounts to 380 million cubic feet,—hence, as the area of the bay is about 2500 million square feet, the excess of inflow was enough to raise the general level by about 1¾ inches. The automatic gage at Babylon showed that between the afternoon of December 7 and the forenoon of December 8 the mean tide level rose by a little less than that amount. (Sheets 115 and 116, Accs. 5540 and 5586.)

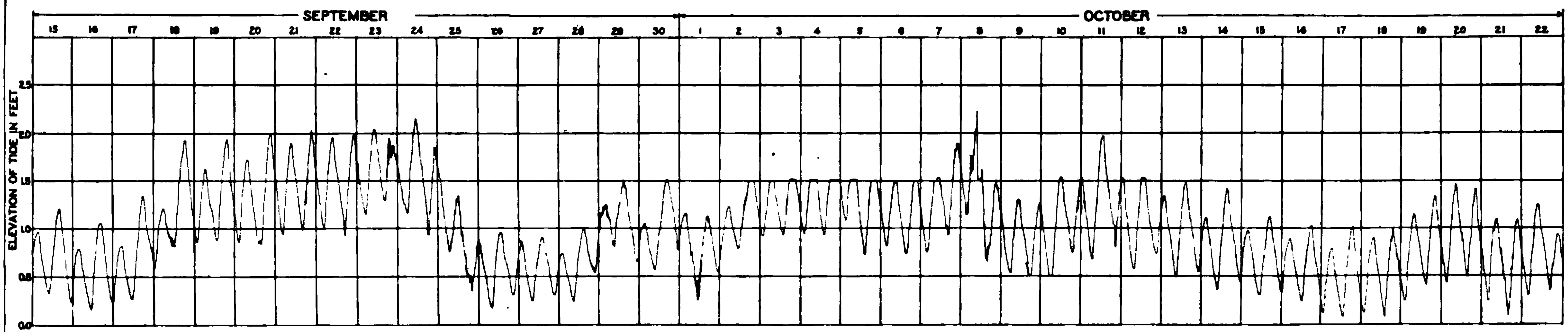
From these data it appears, then, that the volume of water that passes through the Fire Island inlet is in round numbers about 1900 million cubic feet at each tide, or say 3600 million cubic feet per day. This is equivalent to about 1.45 feet over the entire surface of the bay or about 0.7 foot at each tide. Tide levels taken by means of an automatic gage at Babylon from August 8 to January 13, 1908, showed an average tidal range at that point of 0.82 foot.

If the average discharge of water through the inlet is 3600 million cubic feet per day, this amounts to about 27,000 million gallons a day. The total capacity of the bay is about 105,000 million gallons at low tide; hence, the outflow amounts to about a quarter of the volume of the bay at low tide.

Studies of the chlorine contents of the water leaving the bay through the inlet at ebb tide show that the outgoing water contains only about 3.5 per cent. of fresh water, or about 126 million cubic feet of fresh water a day, or about 942 million gallons of fresh water a day. The average yield of the watershed, including the rainfall on the bay, is about 494 million gallons per day; hence, on this basis 53 per cent. of the fresh water that flows out at each tide does not come back into the bay on the next tide.

On both days when current observations were made at the Fire Island inlet the inflow of the water was greater than the outflow from the bay as far as the facts were indicated by observations covering one course of tides. This condition is not the usual one; on the contrary the outflow is, of course, greater. The tidal records at Babylon, however, show marked changes in the level of mean tide, due to astronomical and meteorological causes. The fluctuations due to the former occur at intervals of about two weeks and amount to a foot or less; the differences due to the wind are more irregular.





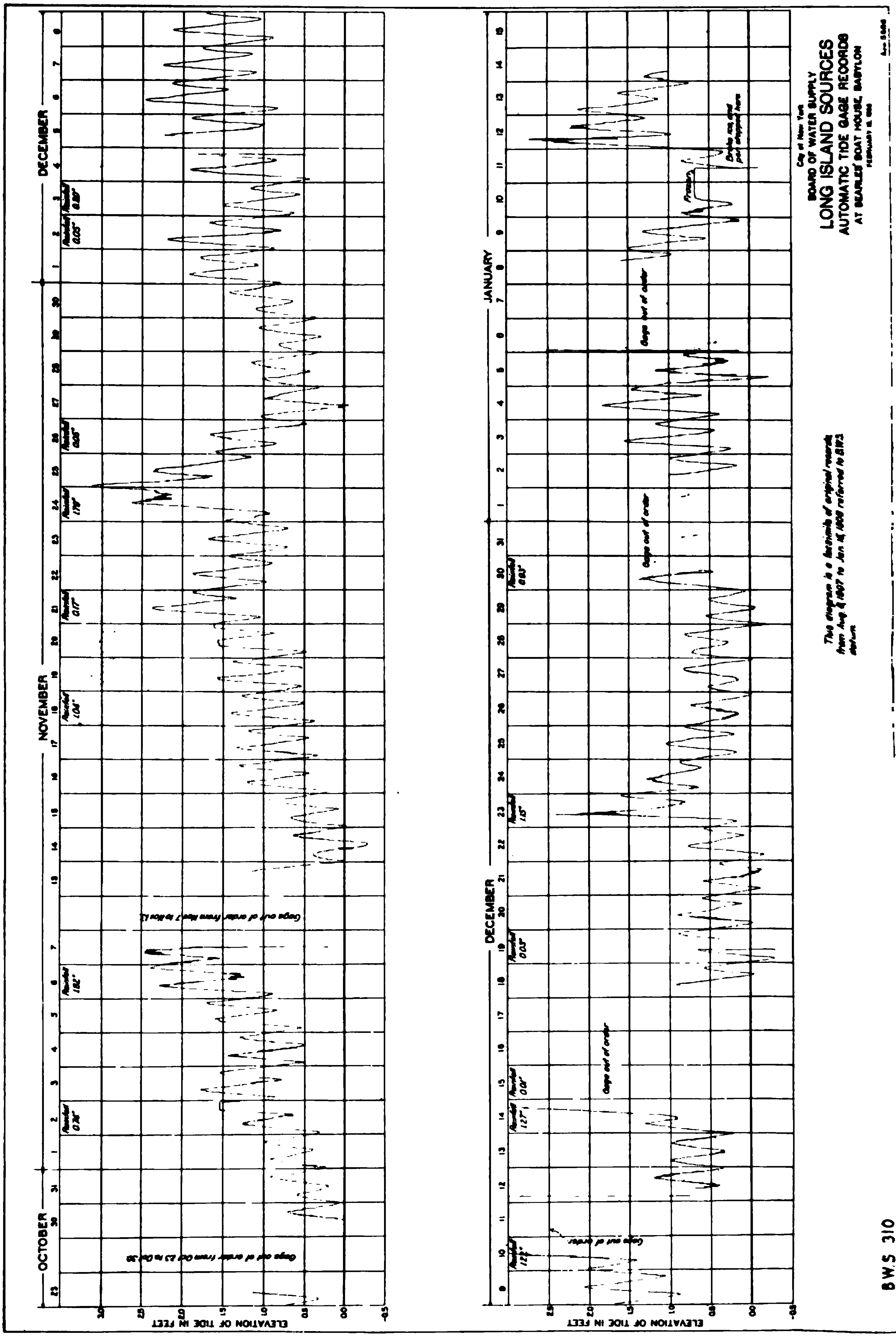
This diagram is a facsimile of original records, from Aug. 8, 1907, to Jan. 15, 1908 referred to B.W.S datum

City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
AUTOMATIC TIDE GAGE RECORDS
AT SEARLES' BOAT HOUSE, BABYLON
FEBRUARY [illegible]

B.W.S. 554

Acc 5540

SHEET 116


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
AUTOMATIC TIDE GAGE RECORDS
AT SEARLES BOAT HOUSE, BABYLON
This diagram is a facsimile of original records from Aug 8 1907 to Jan 15 1908 referred to B.W.S. datum.
ELEVATION OF TIDE IN FEET
OCTOBER
NOVEMBER
DECEMBER
JANUARY
Gage out of order
Frozen
B.W.S. 310

The rainfall materially increases the elevation of the water in the bay. Thus on November 24, 1908, after a rainfall that amounted to 1.72 inches at Moriches and 1.79 inches at Babylon, the elevation of high water increased from 1.45 feet to 3.15 feet.

The data indicate that there may be periods of several days at a time when sea-water is accumulating in the bay, such a period being followed by a complementary period when the accumulated water pours out of the bay.

The results of current observations at various points in the bay are given on Sheet 117, Acc. L 578, and summarized in Table 38.

At the Fire Island inlet the average velocity of the current was about 1.5 miles per hour; at a point opposite Bayshore in the west channel, 0.65 mile; at a point opposite Nicoll's point, 0.60 mile; near Blue Point, 0.24 mile; near Howell's point, 0.35 mile; near the west of Carman's river, 0.17 mile. In the west portion of the bay the current velocity at a point in the main channel opposite Babylon was 0.71 mile per hour; and opposite Breslau (Lindenhurst), 0.31 mile. The maximum velocities were from 25 per cent. to 50 per cent. higher than the mean velocities. The ebb tide velocities were, in general, somewhat higher than those of flood tide. The velocities at the bottom were less than those at the surface.

These figures indicate the existence of currents amply sufficient to supply the oysters with a change of water and bring with it abundance of food supply.

In the middle of the bay, over the main oyster-beds, the average movement of the water back and forth is at the rate of about 0.46 mile per hour. During the ebb tide the water advances in its outward flow about 3 1/3 miles, while during flood tide it is forced back about 2½ miles. The data at hand are not sufficient to enable one to calculate how long it takes a particle of water to flow across and out of the bay, and the figures given serve merely to show the very thorough circulation of water over the oyster-beds by reason of the tidal flow. This is augmented at times by the action of the wind.

The westward growth of the bar at Fire Island inlet is tending to increase the length of the entry channel and this tends to reduce the tidal range of the water in the bays. According to the U. S. Coast Survey, the tidal range of the water at Sandy Hook varies from 4.4 feet to 5.3 feet. The old rec-

TABLE 38

Results of Current Observations in the Great South Bay

Station	Date	Locality	Depth of Water in Feet	Mean Velocities in Feet per Second: Flood Tide Surface	Flood Tide Bottom	Ebb Tide Surface	Ebb Tide Bottom	Maximum Velocities in Feet per Second: Flood Tide Surface	Flood Tide Bottom	Ebb Tide Surface	Ebb Tide Bottom	Direction of Current: Flood Tide	Ebb Tide	Wind: Direction	Wind: Velocity in Miles per Hour
P	Dec. 7, 1907		.	*2.1	.	*1.5	...	*3.5	...	*3.5	.	E	W		
A-B	" 23 "		7	1.2	.9	1.0	.7	1.5	1.0	1.2	1.0	N	S	W	3
J	" 19 "		10	.9	.6	1.3	.7	1.1	.8	1.7	1.0	NE	S	W	7
I	" 18 "		11	.4	.2	.6	.2	.6	.3	.8	.4	SE	W	SW	2
G	" 13 "		9	.7	.3	.7	.4	.9	.4	1.1	.6	SE	W	W	4
H	" 17 "		7	.2	.1	.4	.3	.4	.2	.6	.5	E	SW	W	9
C-D	" 4.5 "		8	.8	.5	1.6	1.3	1.1	.7	2.2	1.9	W	E	NW	9
E	" 6 "		6	.	. .	.6	.3	. .	. .	.7	.5	W	E	W	6

*Mean velocity for total section

ords kept by the government appear to show that the tidal range in the Great South bay is lessening. Between August 1 and 30, 1850, the result of 57 observations showed that the tidal range at the Fire Island inlet was 2.1 feet. Between August 16 and October 15, 1873, the result of 47 observations gave a tidal range of 1.8 feet. Between August 13 and August 31, 1875, the result of 19 observations showed the tidal range to be 1.91 feet. The tidal records kept by the automatic gage at Babylon between August, 1907, and August, 1908, showed the average tidal range at that point to be 0.8 foot.

If the bay had a larger opening the tidal range would be greater, just as it is in Jamaica bay, where it is upwards of four feet. The gradual change of the inlet in the future, if the present growth of the bay continues, will lower the tidal range. This will naturally tend to hold the fresh water in the bay for a longer period than at present and hence to lower the specific gravity of the water over the oyster-beds. Just how great this effect will be cannot be said from any existing data, but its tendency will be to counteract the effect of the proposed diversion of the ground-water.

Temperature

The temperature of the water in the bay was determined during the course of the investigation, but the results are not here included.

Salinity of the Water. Observations Made in 1907

The salinity of the water may be determined in two ways; directly, by ascertaining the amount of chlorine in the water in parts per million, and indirectly by measuring its specific gravity. The relation between the two is shown by the table following.

The sea-water off the southern coast of Long Island normally contains about 17,500 parts per million of chlorine and has a specific gravity of 1.025. The fresh waters that enter the Great South bay have chlorine contents that range from 6 to 16 parts per million, but these figures are so low in comparison with those of sea-water that they may be practically ignored in making calculations. For purposes of comparison the following table has been made out, showing the specific

gravity and the chlorine content of water containing various percentages of sea-water:

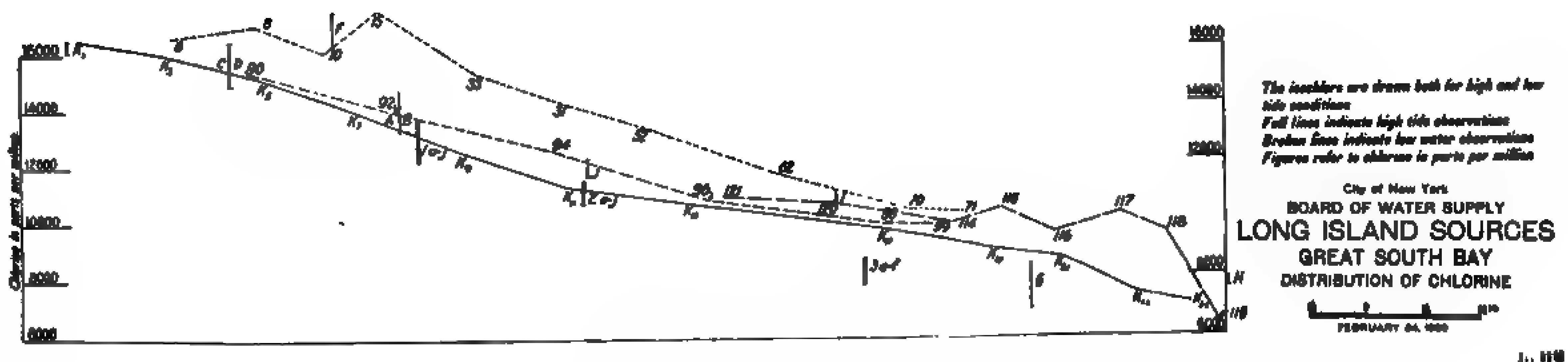
TABLE SHOWING THE RELATION BETWEEN THE SPECIFIC GRAVITY OF SEA-WATER AT 60° F., AND THE CHLORINE IN PARTS PER MILLION

(Based on some experiments made at Mt. Prospect Laboratory, 1903)

Specific Gravity	Chlorine—Parts per Million	*Per cent. of Sea-Water	Chlorine—Parts per Million	Specific Gravity	*Per cent. of Sea-water
1.000	0	..	0	1.000	0
1.001	720	4	1,000	1.0014	6
1.002	1,440	..	2,000	1.0028	11
1.003	2,160	12	3,000	1.0042	17
1.004	2,880	16	4,000	1.0056	23
1.005	3,600	21	5,000	1.0070	29
1.006	4,320	25	6,000	1.0083	34
1.007	5,040	29	7,000	1.0097	40
1.008	5,760	33	8,000	1.0111	46
1.009	6,480	37	9,000	1.0125	52
1.010	7,200	41	10,000	1.0139	57
1.011	7,920	45	11,000	1.0153	63
1.012	8,640	49	12,000	1.0167	69
1.013	9,360	53	13,000	1.0181	74
1.014	10,080	57	14,000	1.0195	80
1.015	10,800	62	15,000	1.0209	85
1.016	11,520	66	16,000	1.0222	92
1.017	12,240	70	17,000	1.0236	97
1.018	12,960	74	17,500	1.0243	100
1.019	13,680	78	18,000	1.0250	...
1.020	14,400	82			
1.021	15,120	86			
1.022	15,840	90			
1.023	16,560	95			
1.024	17,280	99			
1.0243	17,500	100			
1.025	18,000	...			

*Sea-water taken as that containing 17,500 parts of chlorine per million

During November and December, 1907, over 300 samples of water were collected at various points in the Great South bay between Cedar island on the west and Smith's point on the east. At first samples were collected at points somewhat irregularly distributed over the entire bay, but later several series of samples were collected. Three of these series of samples were collected on east and west lines from Babylon to Patchogue. Three series of samples were collected on north and south lines; one opposite Bayshore, one opposite Nicoll's point, and one opposite Blue Point. Seven series were collected at certain fixed points in the bay through a complete course of tides. In addition to these, numerous other samples were collected at random in connection with the taking of samples of oysters. In many cases, especially at first, sam-



The isochlors are drawn both for high and low tide conditions
Full lines indicate high tide observations
Broken lines indicate low water observations
Figures refer to chlorine in parts per million
City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
GREAT SOUTH BAY
DISTRIBUTION OF CHLORINE

ples were collected both at the surface and at the bottom, but after it was found that the differences between the two depths were not very great, many of the surface samples were discontinued, and only the samples at the bottom taken for analysis.

These samples were analyzed for chlorine. Most of the observations were made by Mr. Fred. G. Bennet, Assistant Engineer, many were made in the laboratory of the New York Water Board at Varick street, and a few were made in the laboratory of Hazen and Whipple.

For purposes of study these chlorine observations have been plotted on a map of the Great South bay, Sheet 118, Acc. 5538, according to their location, and from these points lines representing equal amounts of chlorine have been drawn. On this map two sets of lines are shown. First, a series of irregular full lines representing the distribution of chlorine according to those samples that were collected at or near high tide, and second, a series of broken lines based on samples collected at or near low tide.

It will be noticed that the isochlors based on the high tide samples tend to follow the currents that enter the bay. There is, for instance, evidence of the fact that the entering sea-water passes northward through the west channel between Sexton island and Fire island. There is also seen to be a drift of salt water down the center of the bay in a general direction corresponding with the east channel and at the area of deep water. At times of high tide, or when the sea-water is running into the bay, the chlorine contents appear to be somewhat higher in the middle of the bay than at the shores. This is well shown by the high water isochlors in the middle section of the bay. The effect of this appears to be lessened, however, by the time the flow has reached Bellport bay.

The isochlors based on the low tide observations are more regular and show a more uniform distribution of the chlorine in north and south lines, and this is probably due to diffusion and to the intermingling of currents after the water has been for some time in the bay. No doubt the wind has much to do with this mixing of the waters, especially at times when it is blowing freely from the north or south. On account of the greater stability of these low tide isochlors they are more serviceable for use in studying the distribution of sea-water in the bay and in making calculations of what it will be after

a portion of the fresh water now entering the bay has been diverted from it than the high tide isochlors.

Looking at these low tide isochlors, it will be noticed that in the western part of the bay, near the inlet, the lines extend from northwest to southeast, while in the eastern portion of the bay the lines are more nearly north and south. The reason for the general inclination of the isochlors in this northwest and southeast direction is the fresh water that enters on the north side and the fact that the entering currents remain somewhat closer to the sandbar on the south side than to the main shore on the north side. If the observations are studied closely, indications can be seen of the effect of the inflow of the large streams, such, for instance, as that of the Connecticut river. The influence of this stream, taken in connection with that of the promontory known as Nicoll's point, tends to make the water in Nicoll's bay somewhat fresher than it otherwise would be. One curious condition of the distribution of salt water was observed in Bellport bay just east of Howell's point. Here was found a small region considerably more saline than the rest of the water in Bellport bay, and at that point there appears to be a sort of eddy, the fresh water of Carman's river passing westward to the south of it. Whether or not this was influenced by the channel that connects Bellport bay with Moriches bay was not determined. The influence of the greater amount of fresh water entering the bay on the north side than on the south side is shown by the fact that the isochlors on the north side make a sharper angle with the shore than on the south side.

The water in the bay west of the Fire Island inlet is only slightly less saline than the water of the open sea. This is probably due to the fact that it receives water from two inlets, namely, from Gilgo inlet and from Fire Island inlet. Generally speaking, the water in the bay west of Babylon contains from 85 per cent. to 95 per cent. of sea-water. Between Bayshore and Nicoll's point the percentage of sea-water is between 75 and 85. Between Nicoll's point and Blue Point it is between 55 and 75. Between Blue Point and Howell's point it is between 35 and 55, while east of Howell's point in Bellport bay it varies from 35 to 25. In the smaller coves or estuaries of the inflowing streams, the percentage of sea-water varies from this latter figure down to zero. These figures refer to the conditions at low tide. At high tide the

percentages of sea-water are slightly greater. It is needless to state them with great accuracy, however, as they are subject to more or less change according to the volume of stream flow and tidal flow. The latter depends partly upon various astronomical conditions covering the tides, and partly upon the direction and intensity of the wind.

SALINITY OF THE WATER. OBSERVATIONS MADE IN 1908

A preliminary study of the chlorine distribution in the Great South bay was made on July 10, 11 and 12, 1908, when two lines of samples were collected at intervals of about ½ mile between Babylon and Howell's point. Beginning with July 29, 1908, samples were collected with as much regularity as possible at certain chosen places in the bay. It was intended to have the bay covered about once in two weeks, but in order to distribute the samples over the different phases of lunation the plan was adopted of collecting samples on two successive weeks and then skipping two weeks. During the latter part of the investigation the periods were more regular.

The methods of analysis and the general conduct of the investigation were the same as described in my previous report of February 25, 1908, covering the investigations conducted during November and December, 1907.

COMPARISON OF SALINITY DETERMINATIONS IN 1907 AND 1908

The diagrams on Sheet 119, show, in a general way, the differences between the amount of sea-water in the Great South bay during November and December, 1907, and during the period from July 10 to November 20, 1908. The lines on these diagrams show the progressive decrease in the chlorine contents from the Fire Island inlet to the east end of the bay along the central longitudinal axis.

It will be seen that in November and December, 1907, there was a gradual decrease in the chlorine content in an easterly direction from about 17,000 parts per million near the inlet to 6000 parts per million at the east end. During July, 1908, the chlorine in the water showed substantially the same distribution. The summer of 1908 proved to be a dry one and as a result of this the amount of fresh water in the bay decreased, until, at the end of November, the amount of chlorine in the east end of the bay was about 10,000 parts per million

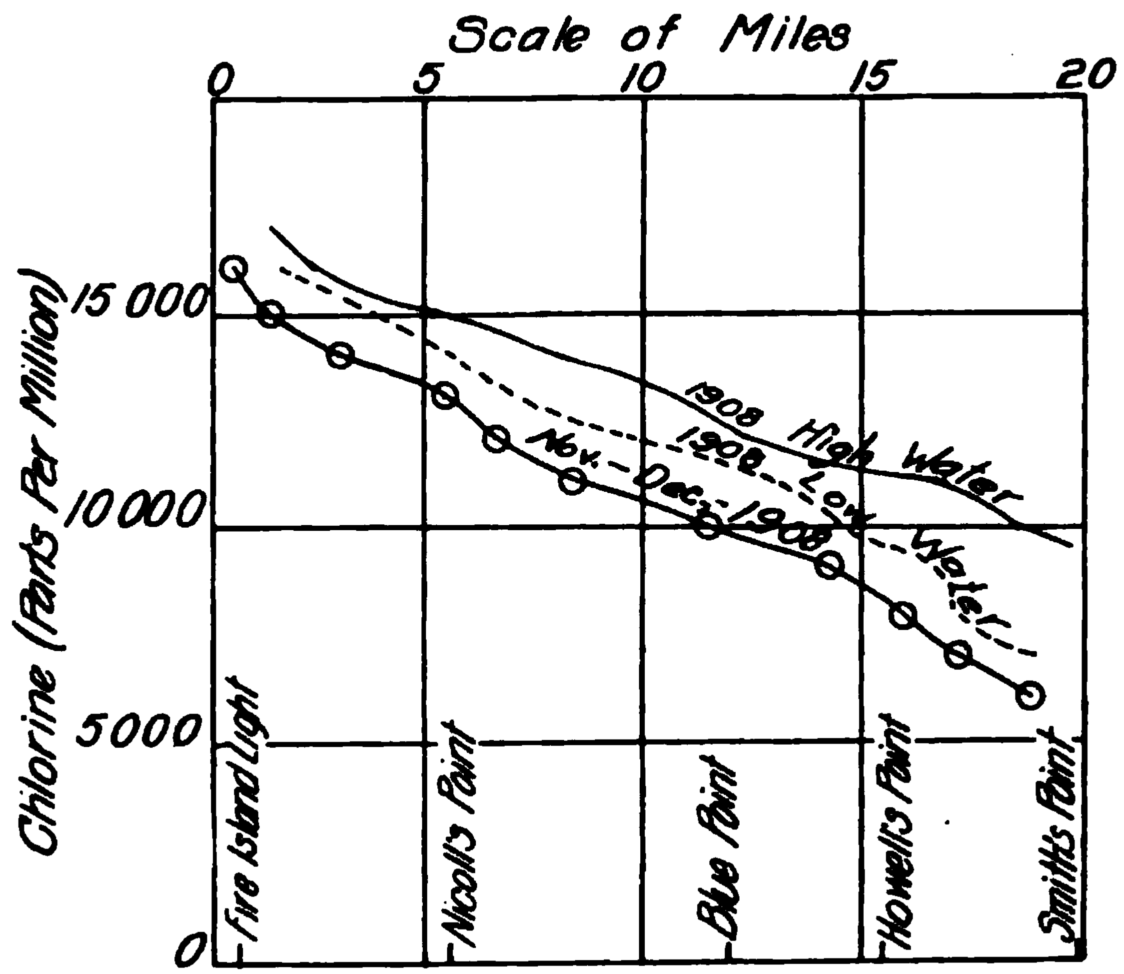


Diagram Showing the Variations in the Chlorine in the Great South Bay in an East and West Direction.

Nov. & Dec., 1907
July- Dec. Spring Tides, 1908
" " Neap " "

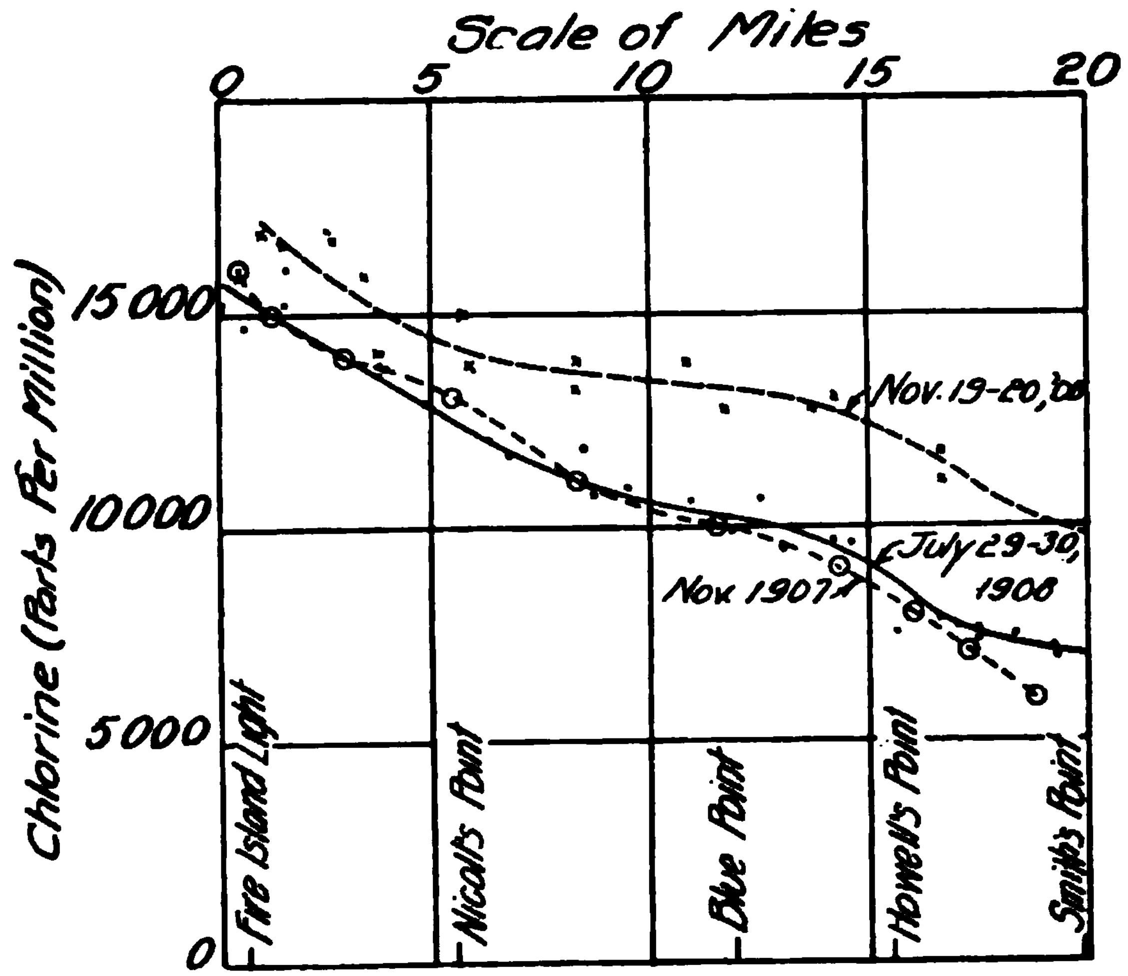


Diagram Showing the Variations in the Chlorine in the Great South Bay in an East and West Direction.

July 29-30, 1908.
Nov. 19-20, 1908
Nov. 19, 1907

instead of 7000 parts per million a few months previous. There was also a corresponding increase in the amount of chlorine at other points in the bay. This increase may not have been entirely due to the dry weather; it may have been due in part to changes in the gates at the easterly end of Shinnecock bay, where there is a connection with the waters of Peconic bay, which resulted in an increased salinity of the water both in Shinnecock bay and in Moriches bay. The data are not sufficient to warrant any definite claim of this kind, but the information obtained appears to indicate that something of the sort probably occurred.

Studies of the chlorine distribution during 1907 showed that at times of high tide the isochlors were somewhat differently located than at low tide. For example, when the water was flowing into the bay, that is, in an easterly direction, the isochlors were convex to the east along the lines of the main channels, but when the tide was going out, that is, when the flow in the bay was westerly, the isochlors were mcre regular across the bay; this being due, apparently, to the mixing of the water. In both cases the isochlors were inclined in a northwest and southeast direction, showing the effect of the greater inflow of fresh water on the northerly side of the bay.

In the observations of 1908 this same general condition was found to prevail, and it was further observed that there were differences in the amount of salt water in the bay that corresponded in a general way with the spring tides and neap tides. The automatic tide gage maintained throughout the season at Babylon, Long Island, showed fluctuations of a foot or more in the mean tide level between the spring tides and the neap tides. Irregular fluctuations also occurred, due to wind and rain. When the mean tide level was high there were also greater variations in the daily range of tide. Thus it happened that when the stage of the water at the mouth of the bay was low there was a greater tendency for ground-water to enter the bay and for an increased flow of water out of the bay. On the other hand, when the water at the inlet was high there was a tendency for the salt water to enter the bay, causing an increase in the amount of chlorine.

In order to determine more closely the exact elevation of the mean sea-level on the chlorine in the bay, series of daily samples were taken during the month of November, 1908, at Babylon, Long Island, at Nicoll's point, at Blue Point, at Bell-

port harbor and at Smith's point, samples being taken both at high tide and low tide. The results of these analyses are shown in the figure on Sheet 120, together with the mean tide level at Babylon and the predicted range of the tide at Sandy Hook as given in government tide tables. The results obtained were somewhat conflicting and are not fully explicable. At the east end of the bay the amount of chlorine in the water appeared to fluctuate more or less directly with the mean tide level of the water, but at the other points mentioned there was no such increase. At Nicoll's point there was a marked increase in chlorine between November 10 and 15 for which no adequate explanation has been found.

It is apparent from these observations that the amount of salt water in the Great South bay is by no means constant. Variation in rainfall make one year different from another year; variation in the mean elevation of the water, due to various astronomical conditions affecting the tides, and to the influence of strong winds, heavy rainfalls, etc., cause periodic changes. Then there are also variations with every tide. In addition to these natural conditions there are the artificial conditions resulting from the manipulation of the gates at Shinnecock.

No observations have been made on the salinity of the water during the spring or the early summer, and it is during the months of May, June and July that the conditions are most critical for oyster culture, for it is at that time of the year that the oysters are spawning and that their real growth occurs. By the end of August the shells of the oysters have very nearly attained the extent of a season's growth and from that time on the physiological processes are merely sufficient to keep the oyster alive until the next growing season. It is fair to assume that during the spring and the early summer the amount of fresh water in the bay is greater than during the fall of the year when the observations on the salinity of the water have been made. It is fair to assume that during this growing period the area within which the water has a favorable specific gravity lies farther to the westward than it does later in the season. Consequently the effect of the diversion of the ground-water on the oyster-beds at that season would naturally be less than later in the summer. It is desirable to have a few series of chlorine determinations made during the months of April, May and June in order to determine the

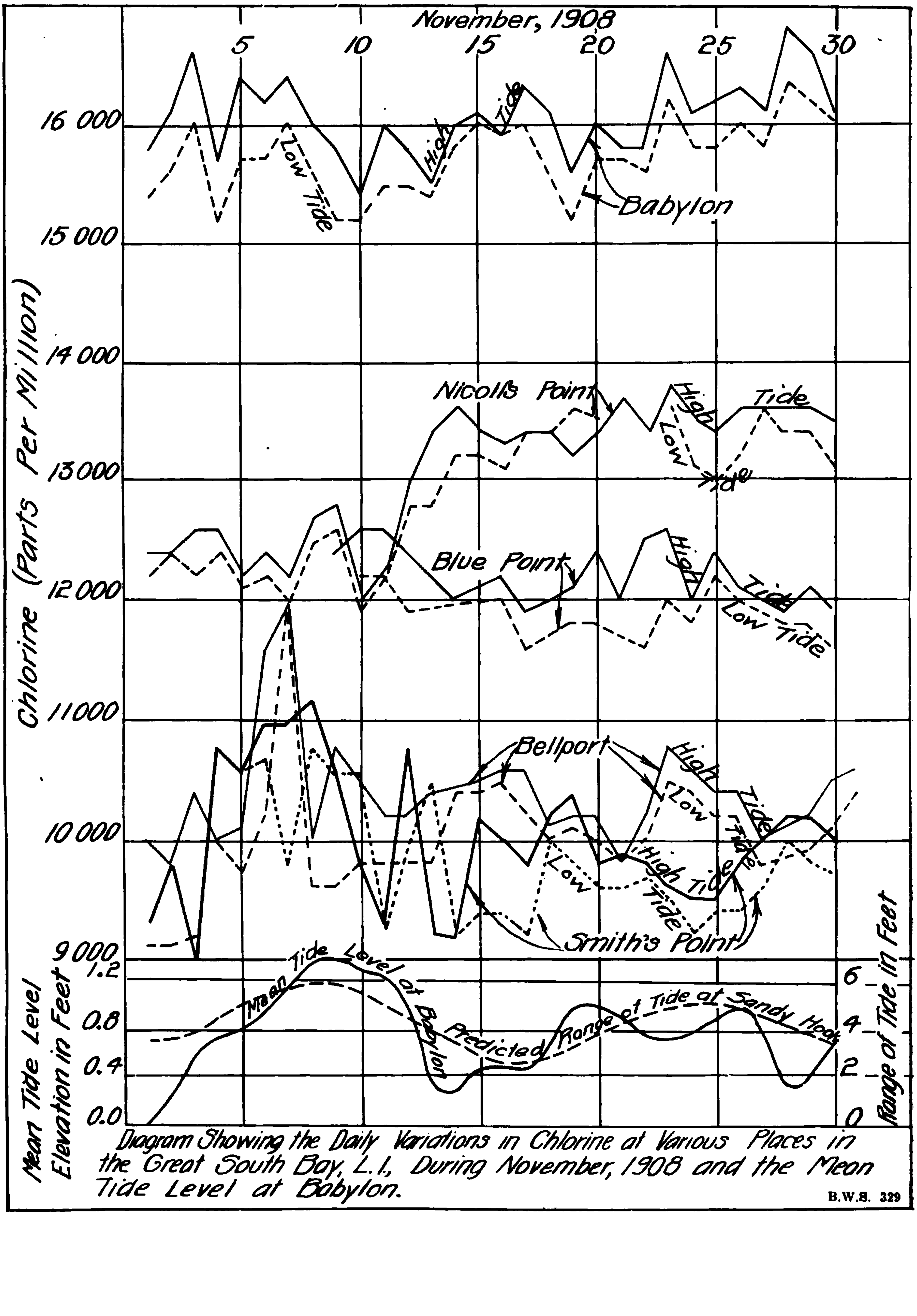
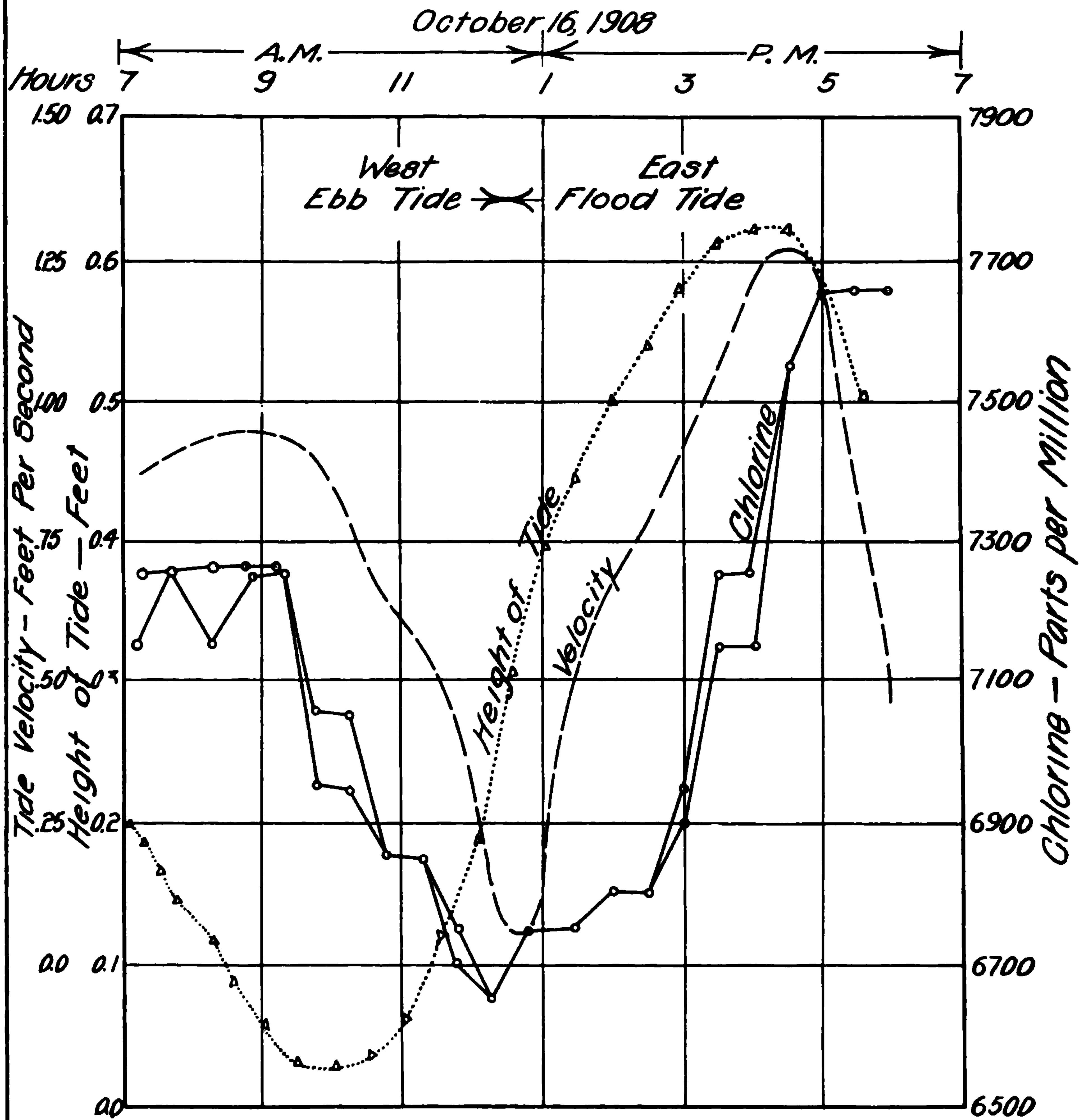


Diagram Showing the Daily Variations in Chlorine at Various Places in the Great South Bay, L. I., During November, 1908 and the Mean Tide Level at Babylon.

B.W.S. 329

Chlorine in the Great South Bay
Comparison of Salinity of Samples of Water taken at Smith's Pt. with Height and Velocity of Tide.



From samples and observations taken in channel at Smith Pt. October 16, 1908.
Approx mean flow 67,000,000 gallons each 6 hours

B.W.S. 324

distribution of the chlorine in the water during the oyster growing season.

The year 1908 may be considered as an abnormal one on account of the low rainfall during the latter part of the summer. Hence the calculations showing the effect of diversion of ground-water at that time ought not to be taken as representative of ordinary conditions. The observations made during July, 1908, and during November and December, 1907, ought to represent much better the average conditions that prevail in the bay and the maps prepared for the year 1907 may be regarded as more nearly expressing the average conditions than those based on the recent data obtained during 1908.

The observations of 1908 are valuable, however, as indicating the important changes that may occur from natural conditions and they serve to explain what the oyster growers have long observed, namely, that no two seasons are just alike; that in some years the oysters grew best in the easterly part of the bay and that in other years they grew best to the westward.

For example, take the case of the spawning of the oyster. This covers a comparatively short period of time and in order that a good set shall be obtained it is necessary that the water be of a proper specific gravity and at a proper temperature. If at a time when the temperature of the water is at its optimum the mean elevation of the water happens to be low, the specific gravity of the water in the eastern part of the bay will be reduced and a good set of oysters will occur, but if at this time the mean tide level happens to be high, the specific gravity of the water in the bay will be increased and the chances of a good set of oysters will be lessened. Some oyster growers claim that there is a relation between rainfall and the set of the oyster. Others claim that there is no such relation, but that temperature is the governing factor. The observations here made appear to indicate that the salinity of the water as affected by tidal conditions probably plays an important part in determining the chances of a good oyster set.

During the fall and winter the effect of the salinity of the water on the oyster is comparatively small. During that period there is no material increase in the size of the shell. There may be, however, differences in the plumpness of the oyster meat and in its keeping quality, due to differences in

salinity of the water. It is claimed by the oystermen, and it seems to be a fact, that oysters that are taken from water in which the specific gravity is comparatively high do not keep as well after being removed from the water as oysters taken from fresher water. Indeed this is one reason why the process of "floating" is resorted to. Oysters taken from waters of unusually high specific gravity are apt to be somewhat less plump than those taken from fresher water. These matters are, however, of very minor importance in comparison with the question of growth that occurs during the spring and early summer.

Salinity of the Water Over the Oyster-Beds

From the data that have been obtained, isochlorine maps of the bay have been drawn showing the salinity of the water over the oyster-beds. Sheet 122, Acc. 5534, shows the line of equal chlorine in parts per million, based on the data obtained in 1907. The oyster-beds are indicated by the cross-hatched areas. Sheet 123, Acc. 5532, shows the specific gravity of the water, deduced from the chlorine determinations. The shaded area lying between specific gravities 1.013 and 1.020 shows the location of the water of most favorable salinity for the growth of oysters, based on the observations made during 1907.

Sheet 124, Acc. 8342, shows the distribution of chlorine between July 20 and November 22, 1908, on the days when the mean elevation of the water was lower than the average for the period. Sheet 125, Acc. 8342, shows the distribution of chlorine for the same period when the mean elevation of the water was higher than the average for the period. Sheet 126, Acc. 8342, shows the isochlorine lines based upon all the determinations made during 1908.

Sheet 127, Acc. 8532, shows the location of the water that had a specific gravity between 1.013 and 1.020. If this is compared with Sheet 123, Acc. 5532, it will be seen that the water most favorable for the growth of oysters was found in 1908 to be several miles further east than it was during 1907. It is evident, therefore, that the water of optimum density does not occupy a constant position in the bay, but changes according to the various meteorological and tidal conditions above enumerated.

SHEET 122

City of New York

BOARD OF WATER SUPPLY

LONG ISLAND SOURCES

GREAT SOUTH BAY

PRESENT DISTRIBUTION OF CHLORINE

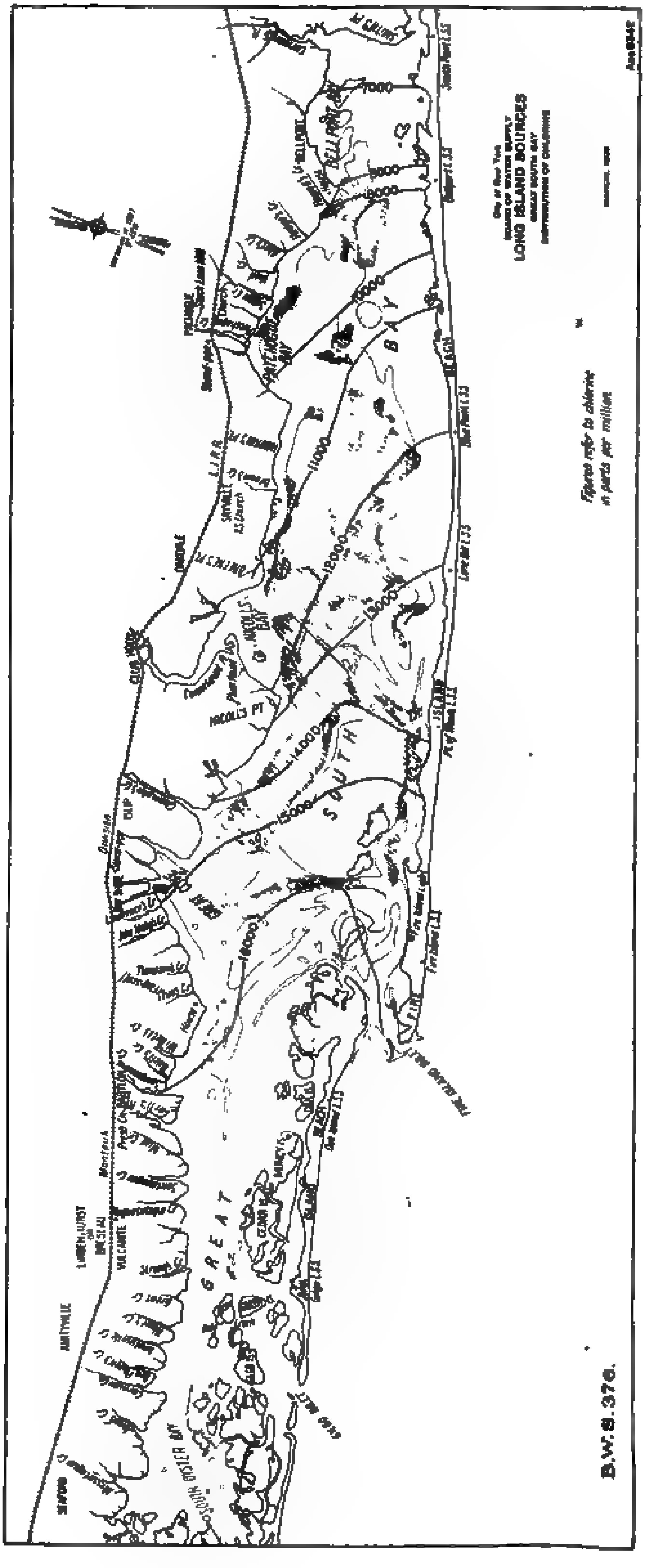
REFERRED TO HIGH TIDE CONDITIONS

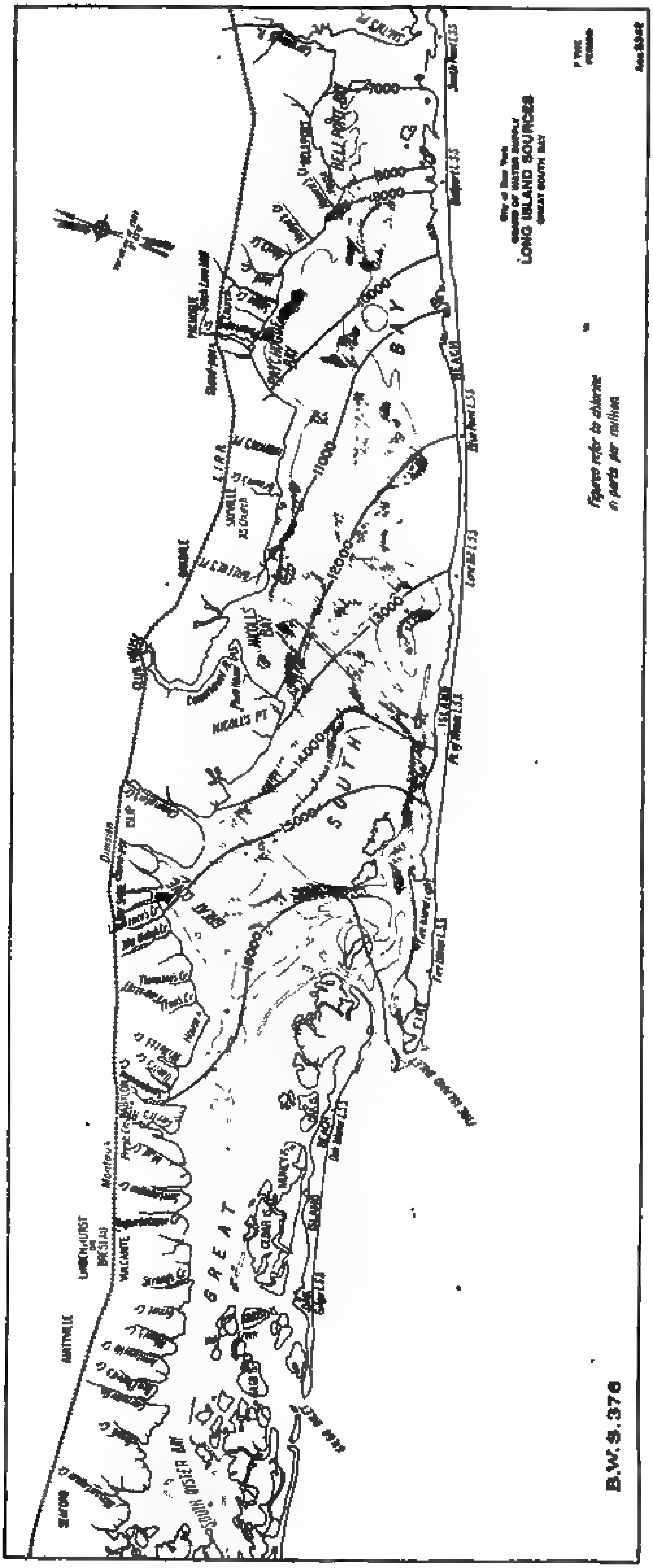
½ 0 ½ 1 Mi.

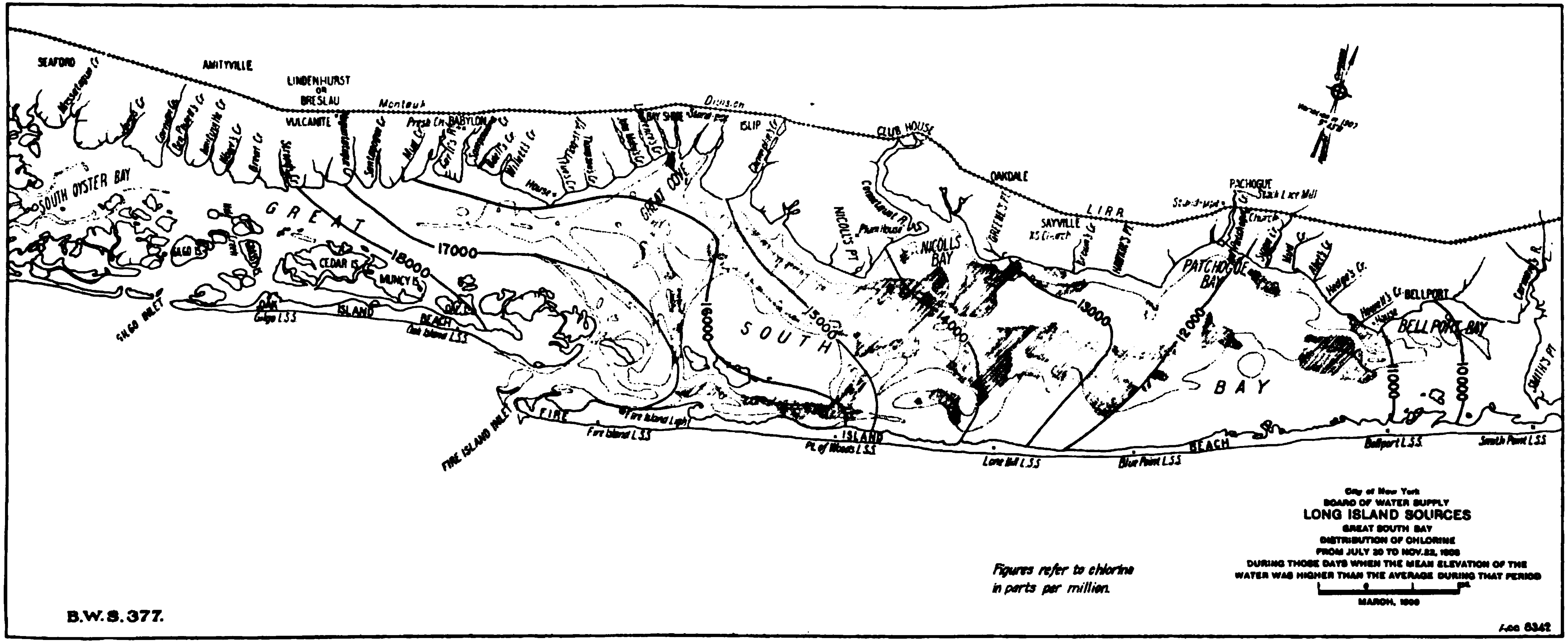
FEBRUARY 24, 1908

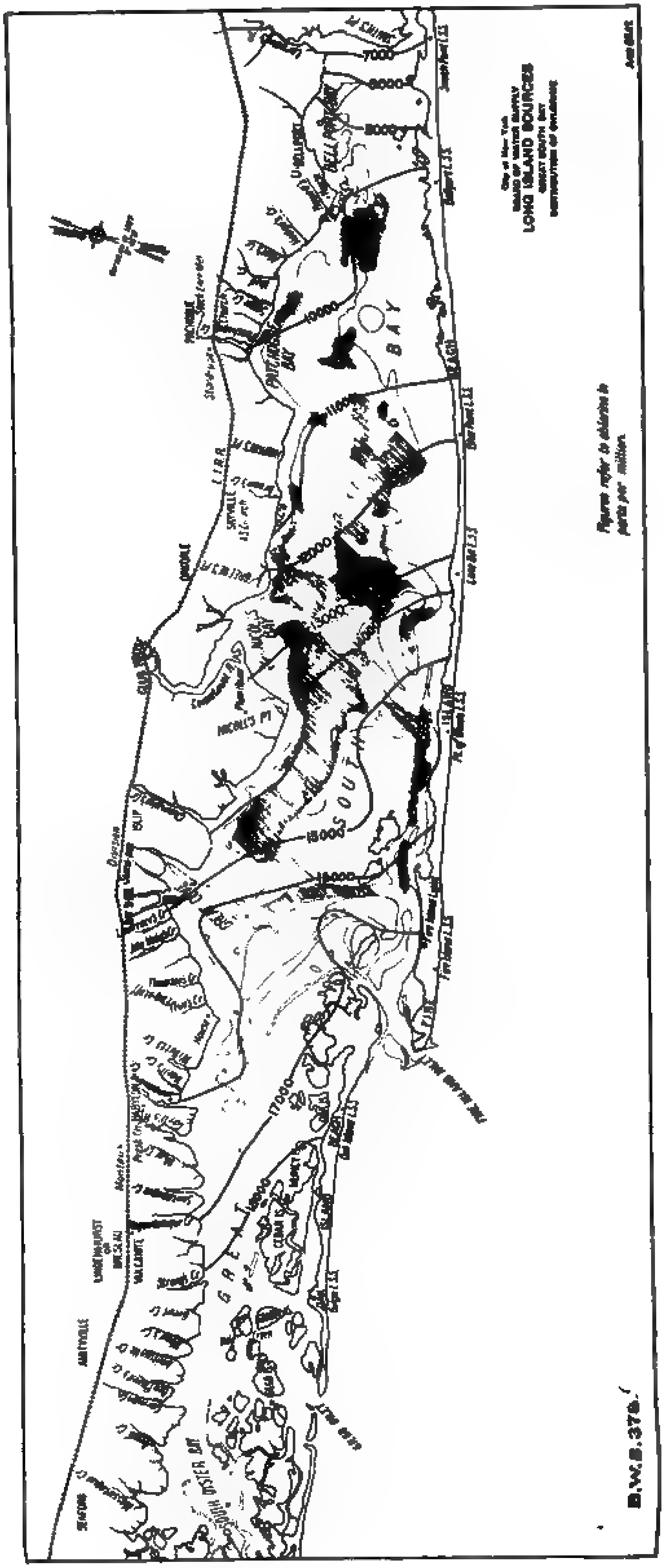
Acc 5534

M. B. BROWN PRINTING & BINDING CO., N. Y.


LONG ISLAND SOURCES
GREAT SOUTH BAY
Figures refer to chloride in parts per million
GREAT SOUTH BAY
B.W.S. 376.


LONG ISLAND SOURCES
GREAT SOUTH BAY
Figures refer to chlorine in parts per million
GREAT SOUTH BAY
SOUTH OYSTER BAY
B.W.S. 376


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
GREAT SOUTH BAY
DISTRIBUTION OF CHLORINE
FROM JULY 20 TO NOV. 22,
DURING THOSE DAYS WHEN THE MEAN ELEVATION OF THE WATER WAS HIGHER THAN THE AVERAGE DURING THAT PERIOD
MARCH,
Figures refer to chlorine in parts per million.
B.W.S. 377.
SEAFORD
AMITYVILLE
LINDENHURST OR BRESLAU
VULCANITE
BABYLON
BAY SHORE
ISLIP
CLUB HOUSE
OAKDALE
SAYVILLE
PATCHOGUE
BELLPORT
L.I.R.R.
SOUTH OYSTER BAY
GREAT SOUTH BAY
GREAT COVE
NICOLLS BAY
NICOLL'S PT
PATCHOGUE BAY
BELLPORT BAY
CEDAR IS.
MUNCY IS.
GILGO INLET
FIRE ISLAND INLET
FIRE ISLAND BEACH
Fire Island Light
Fire Island L.S.S.
Pt. of Woods L.S.S.
Lone Hill L.S.S.
Blue Point L.S.S.
Bellport L.S.S.
Smith Point L.S.S.
Oak Island L.S.S.
Gilgo L.S.S.
10000
11000
12000
13000
14000
15000
16000
17000
18000


Figures refer to chlorine in parts per million.
B.W.S. 378
LONG ISLAND SOURCES
SOUTH OYSTER BAY
7000
8000
10000
11000
15000
17000

The microscopic organisms in the central portion of the Great South bay were found to be somewhat more numerous near the central axis than at the shore. From the Connetquot river to Patchogue all of the samples collected near the north shore contained less than 50 organisms per cubic centimeter, while in the broads the numbers ranged from 50 up to more than 100 per cubic centimeter. A longitudinal series of samples from east to west was collected on December 21, while on December 16 two cross-sections were made, one from Nicoll's point to the Point of Woods, and the other from Blue Point to the Blue Point life saving station. These two cross-sections showed larger numbers in the central portion than near the Long Island shore or the Fire Island shore. From east to west the numbers of organisms differed but very slightly from Bayshore to Patchogue.

On December 19 a series of samples was collected at different hours at Station J. In these samples the numbers of diatoms were about the same as were observed on December 16, but in addition to the diatoms the water contained large numbers of Conferva.

On December 18 a series of samples was collected at Station I at different hours. These samples gave microscopical results slightly lower than were obtained at Station J.

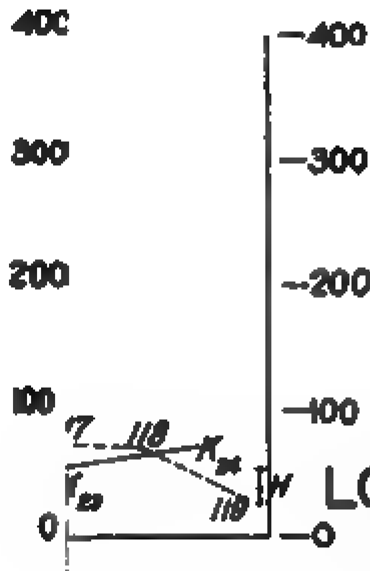
The numbers of microscopic organisms at the east end of the Great South bay; that is, in Bellport bay, were found to be, on the whole, slightly lower than in the central portion. This is shown by the samples taken at Station K-19, 21, 23 and 24, in which the microscopic organisms varied from 24 to 56 per cubic centimeter, while the corresponding figures for the stations in the central portions of the bay varied from 4 to 120 per cubic centimeter.

On December 13 a series of samples was collected at Station G at different hours, which contained from 18 to 36 organisms per cubic centimeter. On December 17 a series of samples was collected at Station H in which the organisms varied from 24 to 52 per cubic centimeter.

At the most easterly stations in Bellport bay,—that is, near the mouth of Carman's river, the water contained rather more organisms than in the waters of Bellport bay. Some of these, however, were different in character from the other organisms and resembled those species found in fresh water,—as, for instance, Tabellaria.

The following table shows the principal genera that were observed in the waters of the Great South bay during the investigation of 1907, and also the largest number of each kind found in any one sample:

	Maximum number of organisms per cubic centimeter
Diatoms	
Amphiprora	5
Amphora	2
Biddulphia	22
Cocconeis	5
Coscinodiscus	8
Cyclotella	56
Cymbella	15
Diatoma	10
Eunotia	32
Fragillaria	32
Isthmia	1
Melosira	32
Meridion	2
Navicula	32
Nitzschia	6
Odontidium	15
Pleurosigma	48
Surirella	12
Synedra	118
Tabellaria	32
Other Organisms Found	
Arcella	4
Ciliata	16
Conferva	320
Difflugia	10
Glenodinium	4
Oscillaria	2
Pine Pollen	8
Peridinium	2
Sponge spicule	4



indicates where organisms are above 50 per cubic centimeter

indicates where organisms are below 50 per cubic centimeter

City of New York

BOARD OF WATER SUPPLY

LONG ISLAND SOURCES

GREAT SOUTH BAY

DISTRIBUTION OF MICROSCOPIC ORGANISMS

FEBRUARY 24, 1906

File D12 L1 Acc 5536

M. B. BROWN PRINTING & BINDING CO., N. Y

The distribution of the microscopic organisms is shown graphically on a map of the bay, Sheet 128, Acc. 5536.

The water entering the bay at Fire Island inlet contained, in round numbers, from 25 to 50 diatoms per cubic centimeter.

The water in the Great South bay west of the Fire Island inlet contained from 50 to 150 diatoms per cubic centimeter.

The water in the middle portion of the Great South bay contained from 50 to 150 diatoms per cubic centimeter, except near the shores, where the numbers fell below 50.

In Bellport bay the diatoms were slightly less abundant than in the central portion of the Great South bay.

The organisms entering the Fire Island inlet and those found in the Great South bay west of the inlet comprise many genera which are distinctly of a marine type. The organisms found in Bellport bay at the mouth of Carman's river are more nearly like those found in fresh water. The organisms found in the central portion of the Great South bay, where oysters are chiefly grown, comprise genera of both groups. The differences between fresh-water genera and marine genera are somewhat vague, but generally speaking, most of the organisms found growing in Great South bay may be classed as brackish water growths. Some of the forms found doubtless have the power of growing in fresh water, but, as a matter of observation, they are not found in any quantity in the streams entering the bay. Without doubt some of the organisms found in the oysters enter the bay with the river-water, while many others enter the bay from the ocean; but in all probability most of the organisms that form the food of the oysters represent growths that have taken place in the brackish water of the bay itself.

The analyses of the water samples that have been made indicate that the water of the Great South bay is a fertile feeding ground for oysters, the numbers of diatoms being generally higher than the figures set by oyster experts as indicative of a satisfactory amount of food supply. Several factors probably contribute to this condition. The bay is land-locked and is comparatively shallow, hence, the temperature conditions are likely to be favorable, the water inside the bar being warmer than that outside during the summer season. The presence of large areas of shallow water offers excellent opportunity for such diatoms as tend to grow on the bottom,

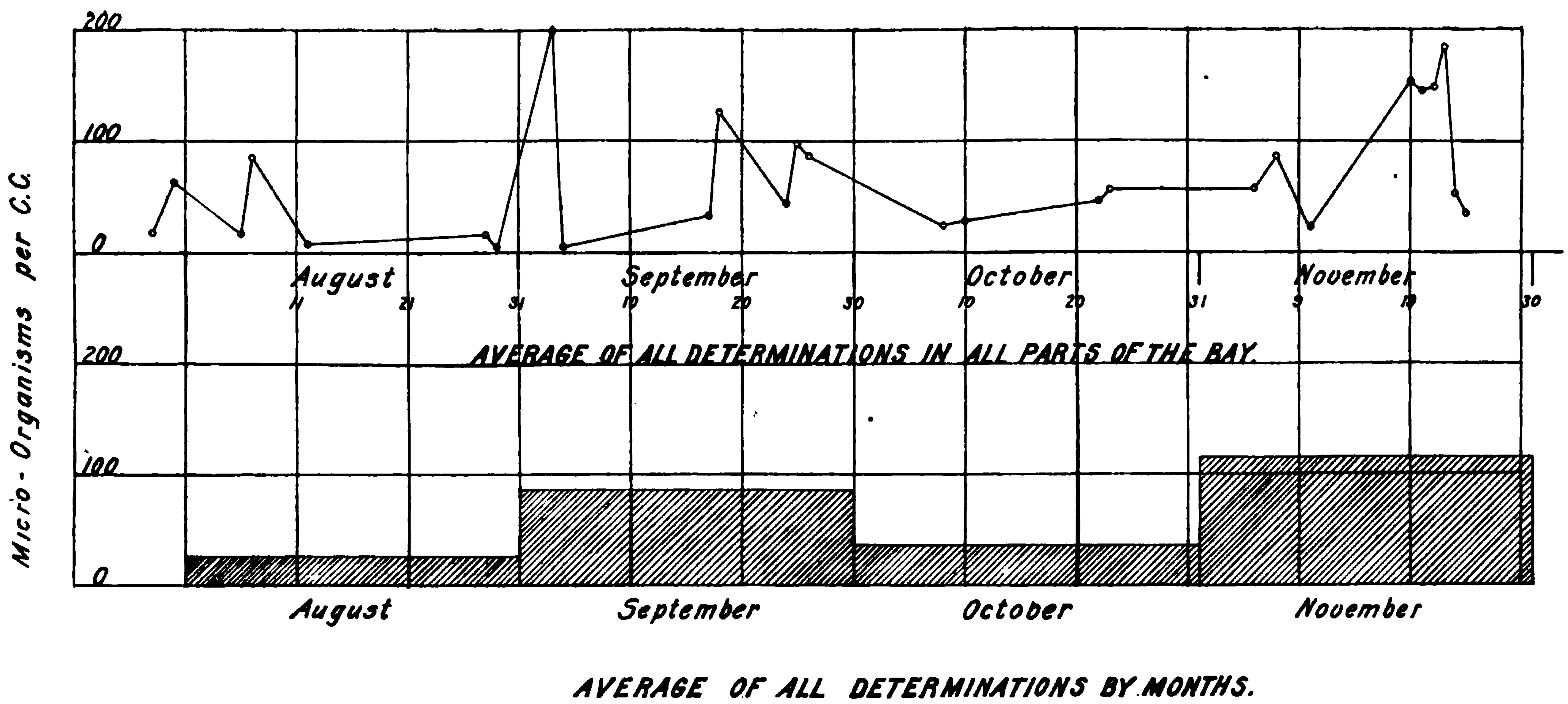
while the deeper and clearer waters give opportunities for the growth of pelagic forms. Without doubt the presence of a considerable percentage of fresh water in the bay tends somewhat to stimulate the growth of these organisms. It is a fact well known among water-works engineers that if ground-waters are stored in reservoirs exposed to the sunlight, heavy growths of diatoms will occur. There seems to be no reason why this may not be the case in the Great South bay and that the ground-water entering the bay at the bottom in the form of springs may tend to stimulate growths of these organisms. There are no exact data, however, to show whether this actually occurs. The analogy of the growth of diatoms in bodies of fresh water must not, however, be carried too far, for it has been found that the principal species of diatoms observed in the bay are not fresh-water forms, but those that thrive best on brackish waters, while, furthermore, the laboratory experiments have shown that in a series of water of varying chlorine contents, seeded with the same organisms, the most intense growths did not occur in those containing the largest proportion of fresh water, but in those which contained rather more salt water than fresh water. In other words, experiments show, as one might naturally expect, that the diatoms characteristic of brackish waters grew best in waters of a mean salinity.

Microscopic Organisms. Observations in 1908

The results of the microscopical analyses made during the season of 1908 have been tabulated and a summary of the results shown in a series of diagrams. The results were reported not in terms of standard units but in "numbers of organisms per cubic centimeter." By far the largest proportion of the microscopic organisms found in the water were diatoms, but there were a few green algæ, protozoa and minute crustaceæ. The diatoms claimed principal attention as they form the bulk of the food supply of oysters.

Distribution of Diatoms

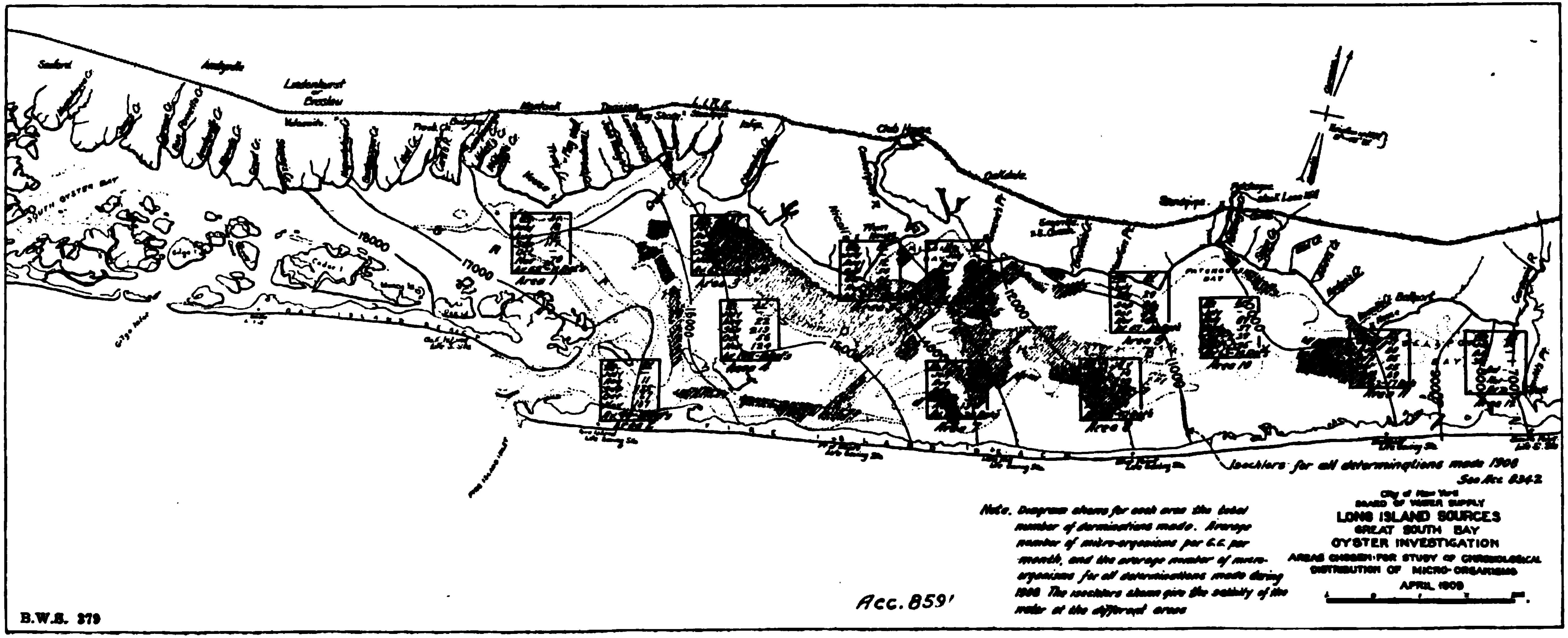
The analyses have been studied in various ways in order to determine, if possible, some of the factors that influence the distribution of the diatoms in the bay. The results of these studies are given in a series of six diagrams, Sheets 129 to 134 inclusive, Accs. 8591 to 8596 inclusive, these diagrams being based on the data given in the tables.

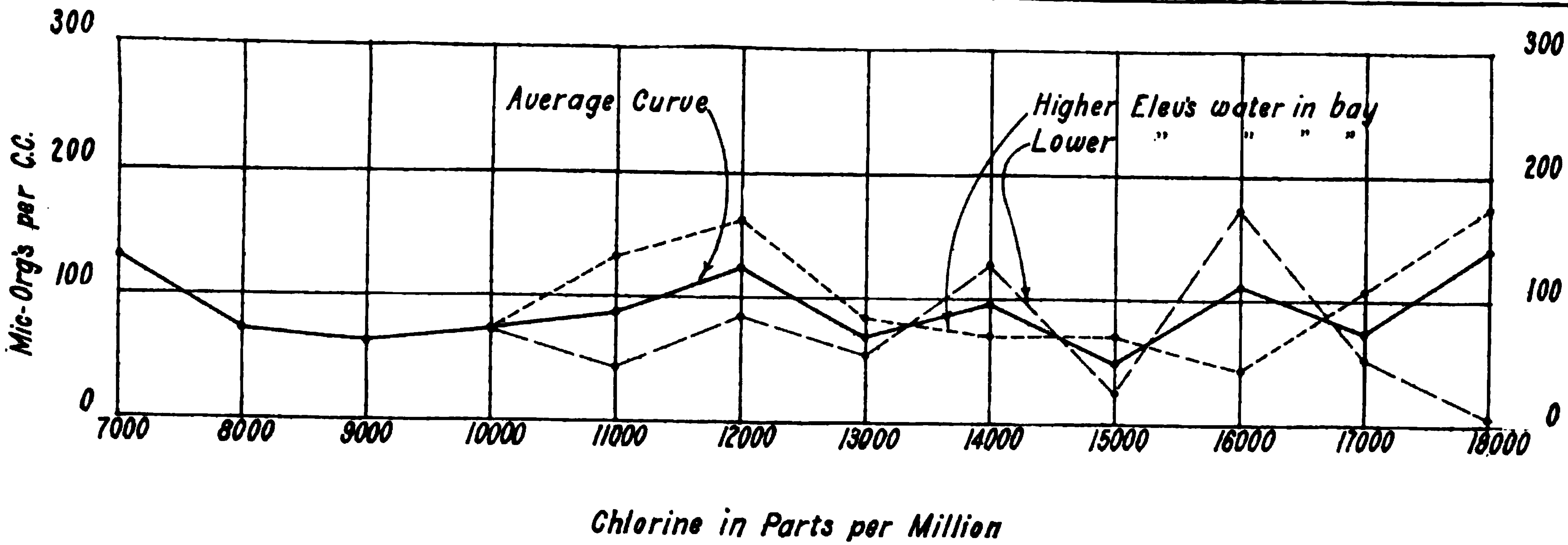


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
GREAT SOUTH BAY
OYSTER INVESTIGATION
CHRONOLOGICAL DISTRIBUTION OF MICRO-ORGANISMS
APRIL, 1909

B.W.S. 518

Acc 8593


Sayville
L.I.R.R.
Club House
Oakdale
Stand pipe
Area 1
Area 2
Area 3
Area 4
Area 5
Area 6
Area 8
Area 10
Area 11
Area 12
17000
16000
15000
12000
11000
9000
7000
Isochlors for all determinations made 1908
See Acc. 8342
Note. Diagrams shows for each area the total number of determinations made. Average number of micro-organisms per C.C. per month, and the average number of micro-organisms for all determinations made during 1908 The isochlors shown give the salinity of the water at the different areas
City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
GREAT SOUTH BAY
OYSTER INVESTIGATION
AREAS CHOSEN FOR STUDY OF CHRONOLOGICAL DISTRIBUTION OF MICRO-ORGANISMS
APRIL 1909
Acc. 859'
B.W.S. 379

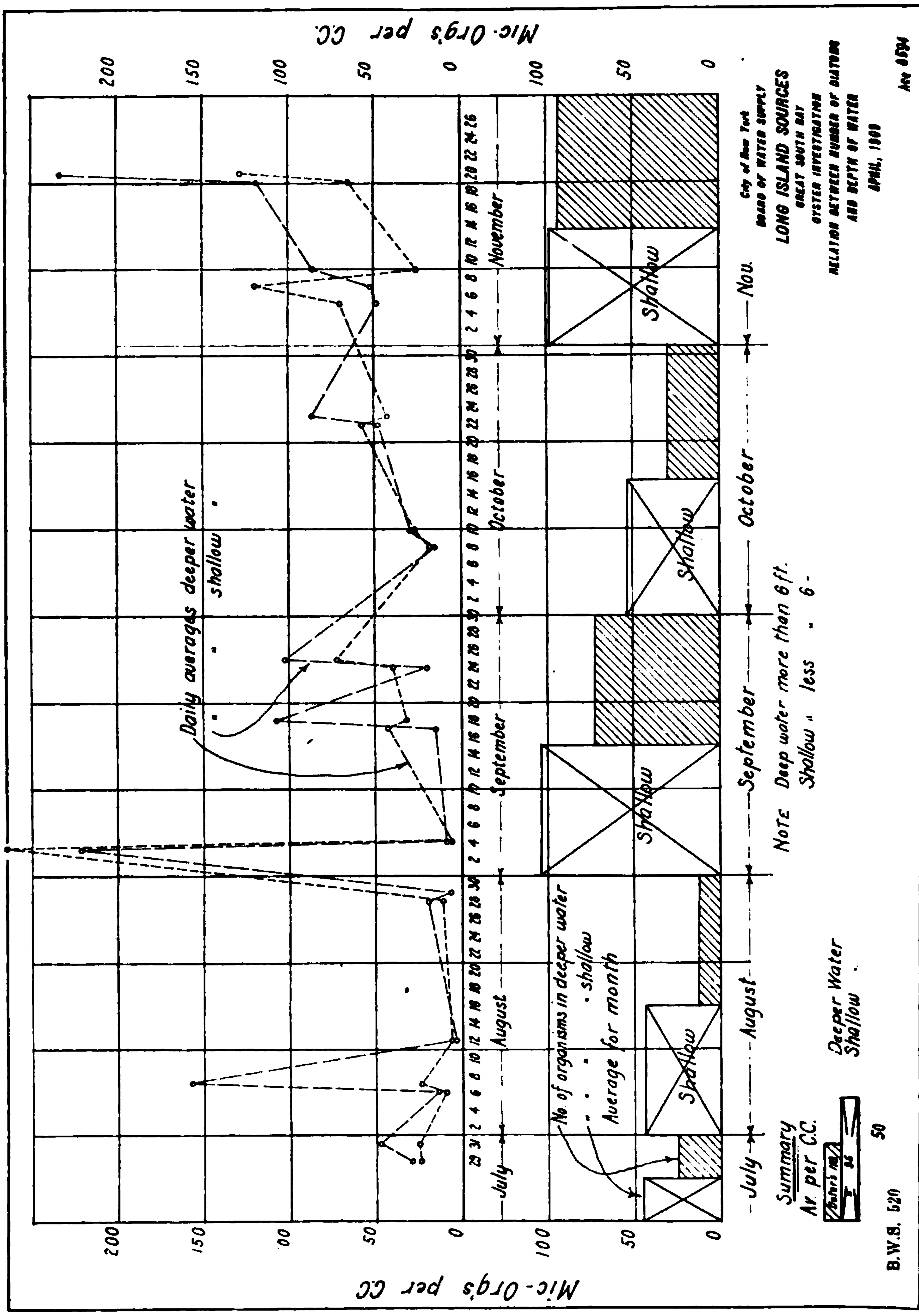


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
GREAT SOUTH BAY
OYSTER INVESTIGATION
RELATION BETWEEN NUMBER OF DIATOMS
AND SALINITY OF WATER
APRIL, 1909

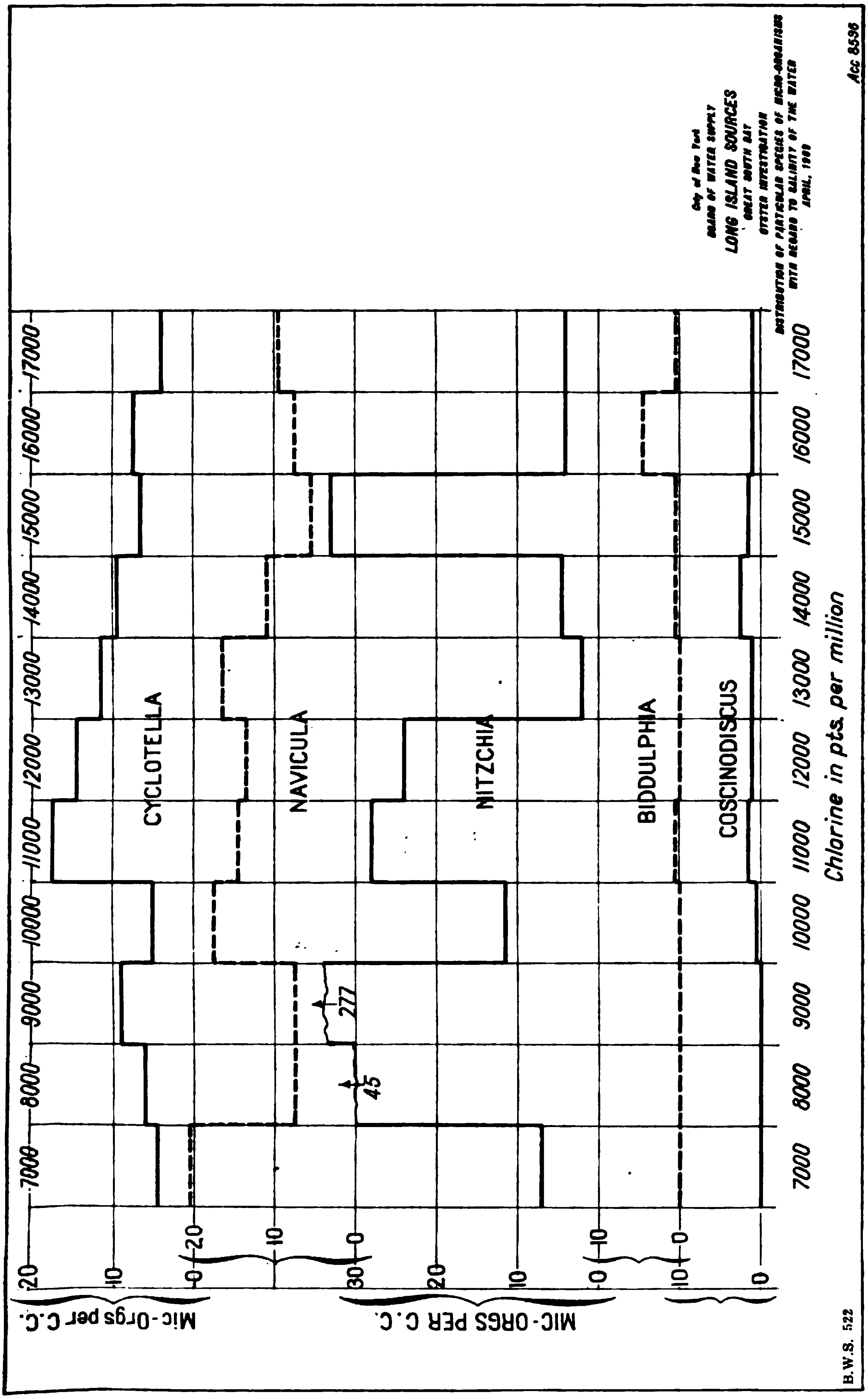
B.W.S. 552

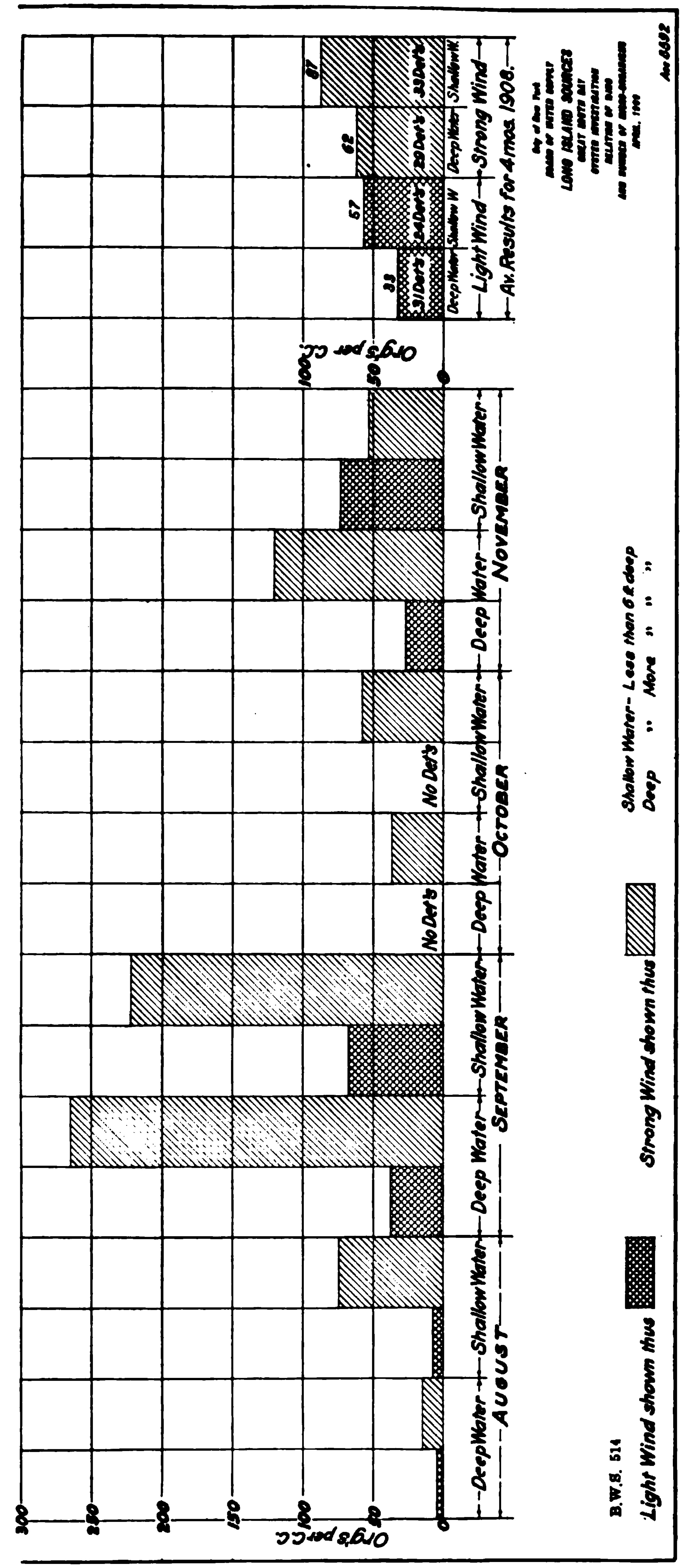
Acc 8595

SHEET 132



Mic-Org's per C.C.
200
150
100
50
0
July
August
September
October
November
Nov.
Daily averages deeper water
shallow
No. of organisms in deeper water
shallow
Average for month
Shallow
NOTE Deep water more than 6 ft.
Shallow " less " 6 "
Summary
Av. per C.C.
Deeper Water
Shallow
City of New York
Board of Water Supply
LONG ISLAND SOURCES
GREAT SOUTH BAY
OYSTER INVESTIGATION
RELATION BETWEEN NUMBER OF DIATOMS AND DEPTH OF WATER
APRIL, 1909
B.W.S. 520


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
GREAT SOUTH BAY
OYSTER INVESTIGATION
DISTRIBUTION OF PARTICULAR SPECIES OF MICRO-ORGANISMS
WITH REGARD TO SALINITY OF THE WATER
APRIL, 1909
Acc 8596
CYCLOTELLA
NAVICULA
NITZCHIA
BIDDULPHIA
COSCINODISCUS
277
45
7000
8000
9000
10000
11000
12000
13000
14000
15000
16000
17000
Chlorine in pts. per million
Mic-Orgs per C.C.
MIC-ORGS PER C.C.
B.W.S. 522


Org's per C.C.
0
50
100
150
200
250
300
Deep Water
Shallow Water
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
No Det's
No Det's
Light Wind
Strong Wind
Av. Results for 4 mos. 1908.
31 Det's
24 Det's
20 Det's
33 Det's
33
57
62
87
Light Wind shown thus
Strong Wind shown thus
Shallow Water - Less than 6 ft. deep
Deep " - More " " "
B.W.S. 514

Sheet 129, Acc. 8593, shows the average number of diatoms in certain selected areas in different parts of the bay, arranged by months. The average numbers of diatoms present in these areas during the entire period of investigation were as follows:

Area	Number of Diatoms per Cubic Centimeter	Location
1	68	South of Conklin's point
2	76	North of Fire Island light
3	62	South of Islip
4	108	North of Old Fire island
5	44	South of Nicoll's point
6	89	South of Greene's point
7	85	North of Lone Hill life-saving station
8	88	North of Blue Point life-saving station
9	47	South of Blue Point
10	63	South of Patchogue creek
11	62	South of Howell's point
12	70	West of Smith's point

It will be seen from these figures that there is no great degree of regularity in the distribution of the diatoms in different parts of the bay. Their occurrence appears to be governed by other things than location in the bay.

Sheet 130, Acc. 8591, shows the chronological distribution of the diatoms in these twelve areas, from the latter part of July until the end of November. During this period there was a gradual increase in the number of diatoms present in the areas in the central part of the bay. This increase was not as marked in the areas in the easterly end and westerly end. During the period the numbers fluctuated widely on different days.

The number of diatoms found in the areas where the water was shallow appeared to be somewhat greater than in the areas of deep water; thus, comparing Area 4 in the shallow water north of Old Fire island with Area 3 just north of it, where the water was deeper, it is seen that the diatoms over the flats were much more numerous than in the deeper water. This is also found to be true if Area 8, north of the Blue Point life-saving station, is compared with Areas 9 and 10, located in the deep water of Patchogue bay. In order to determine this point more definitely a special study was made to find the difference between the organisms present in the samples collected where the water was less than six feet deep with those parts of the bay where the depth was greater than six feet. The results of this study are shown on Sheet 132,

Acc. 8594. It was found that the average number of diatoms per cubic centimeter in 95 samples collected in the shallow water was 70.3, while the average number found in 118 samples collected in deeper water was only 44 per cubic centimeter. This difference between the deep and shallow water seemed to be a constant one. In November, however, the difference was less marked than in the preceding months.

It would be natural to expect diatoms to grow more rapidly on the bottom of the bay in shallow water than in deep water, on account of receiving a greater amount of light, but it seems to be a fact that the occurrence of the diatoms in the water over the shallow areas is also influenced by the wind.

In order to show this relation between the occurrence of diatoms and the intensity of the wind, Sheet 134, Acc. 8592, has been prepared. In this diagram the results obtained on those days when there was a light breeze have been separated from those on which there was a strong wind, comparison being made both for deep water and shallow water. It will be seen from this diagram that the smallest numbers of diatoms occurred in deep water when there was a light wind, and that the largest numbers occurred in shallow water when there was a strong wind. Thus:

		Number of Determinations	Number of Diatoms
Deep water	Light wind	31	33
Deep water	Strong wind	29	62
Shallow water	Light wind	24	57
Shallow water	Strong wind	33	87

The effect of the wind is best illustrated during the month of September when the differences in the wind were quite marked. During this month the numbers of diatoms observed on days when the wind was light varied on an average from about 38 to about 68, while on days when the wind was strong the numbers varied on an average from 240 to 265 per cubic centimeter.

If the diatoms are considered as a class there seems to be comparatively little difference between the numbers observed and the amount of chlorine in the water. This is shown on Sheet 131, Acc. 8595. If, however, individual species are considered, the influence of the chlorine is often marked. Certain diatoms appear to grow best in compara-

tively salt water. Other diatoms appear to grow best in waters that are nearly fresh, while still others multiply most rapidly in waters that are brackish.

Sheet 133, Acc. 8596, shows the relation between the amount of chlorine and certain species of diatoms. Biddulphia is essentially a salt-water form. Nitzschia, on the other hand, appears to grow best in waters where the chlorine is comparatively low, although it is found in all parts of the bay and usually in quite large numbers. Navicula also appears to be favored by water not too heavily charged with salt. Cyclotella is one of the forms that grows best in waters of moderate salinity. Although this organism is found in all parts of the bay it appears to be present in greatest numbers in the middle of the bay, the maximum being observed in water having a salinity of 11,000 parts per million of chlorine. This is an important fact, as the Cyclotella is one of the most important food diatoms of the oyster. Such organisms as Nitzschia, which are long and slender, are not as frequently found in the stomachs of the oysters as the circular forms of Cyclotella and Coscinodiscus. The oyster appears to exert a selective action, to some extent at least, in the choice of its food.

It appears from the studies that have been made that the great source of the oysters' food supply in Great South bay is to be found in the large areas of shallow water. The oysters themselves are located in the deeper waters. The effect of the wind in stirring up the water over the flats thus tends to increase the supply of diatom food and thereby tends to make the conditions of oyster growth more favorable. There is no reason to believe that the growth of diatoms over the flats would be very materially altered by changes in the salinity of the water, although this might be true to some extent. So far as food supply is concerned, therefore, there is little reason to believe that the diversion of fresh water from the bay for the supply of Brooklyn would influence the food supply of the oysters to any material extent.

Laboratory Experiments on the Growth of Diatoms

In order to determine whether or not the salinity of water affected the growth of diatoms, some laboratory experiments were begun on December 19, 1907. A sample of water from Fire Island inlet was collected and diluted with distilled water so as to get a series of water in which the chlorine varied from

about 4000 to 16,000 parts per million. Samples of the Great South Bay water were also collected from a point south of Nicoll's point from Bellport bay and from the Connetquot River inlet, in which the chlorine ranged from about 2,000 to about 12,000 parts per million.

Two litres of these various samples were carefully filtered through sand in order to remove any microscopic organisms present. Portions were then put in battery jars and placed in the window of the laboratory, each jar being seeded with diatoms, filtered from the Great South Bay water, in such a way that each sample contained about 100 diatoms per cubic centimeter, made up of presumably the same genera in each case.

After an exposure of three weeks, and again after four weeks, and six weeks, portions of water were withdrawn from each jar and examined microscopically. The results of these examinations were as follows:

	Fire Island Inlet Diluted with Distilled Water	Fire Island Inlet Diluted with Distilled Water	Fire Island Inlet	Fire Island Inlet Diluted with Distilled Water	Connectquot Inlet	Bellport Bay	Great South Bay South of Nicolls Point
Number of Sample	1	2	3	4	6	7	8
			JARS EXAMINED ON JANUARY 9, 1908				
Synedra.........	4	2	88	24	12	12	484*
Navicula........	8	...	...	4	..	4	4
Nitzschia........	4	...	...	.....	..	..	....
Pleurosigma.....	...	4	...	.....	4	..	....
Ciliata..........	...	12	...	.....	..	..	....
Melosira........	...	...	8	4	..	..	....
Cyclotella.......	...	...	84	60	..	12	8
Conferva........	...	...	8	.....	..	..	....
Scenedesmus.....	...	...	...	.....	4	..	....
Synedra Pulchella.	...	...	...	.....	..	..	....
Total.......	**16**	**20**	**188**	**92**	**20**	**28**	**500**
			JARS EXAMINED ON JANUARY 21, 1908				
Synedra.........	180	24	42	12,000	..	..	....
Navicula........	...	4	...	.....	5	54	1,200
Cyclotella.......	...	...	18	.....	..	5	....
Difflugia........	..	...	4	.....	..	..	....
Scenedesmus	...	...	...	75	..	..	....
Tabellaria.......	...	...	...	10	..	10	....
Pleurosigma.....	...	...	...	.....	..	..	....
Total.......	**180**	**28**	**64**	**12,085**	**5**	**69**	**1,200**
			JARS EXAMINED ON FEBRUARY 5, 1908				
Synedra.........	600	240	800	13,000	52	52	1,200
Melosira........	...	...	20	.....	..	..	....
Navicula........	...	...	12	Cyclotella8	4	..	....
Ciliata..........	...	...	80	.....	..	..	....
Total.......	**600**	**240**	**912**	**13,008**	**56**	**52**	**1,200**

*Flat bands

The following summarized figures show the relation between the growths of diatoms and the amount of chlorine in

the water. It is very noticeable that the largest growths of diatoms occur in the two samples that contain approximately 12,000 parts of chlorine per million. Whether these results are accidental, or whether they actually show a definite relation between the chlorine contents and the diatom growths, cannot be determined, perhaps, from a single experiment like this, but it is worthy of note that the largest numbers of microscopic diatoms are found near the center of the bay where the average chlorine is not far from that which gave the maximum growths of diatoms in the jars.

SUMMARY—MICROSCOPIC ORGANISMS PER CUBIC CENTIMETER

	Chlorine	After Three Weeks	After Four Weeks	After Six Weeks
Fire Island Inlet water	16,215	188	64	912
Fire Island Inlet water diluted with distilled water	12,080	92	12,085	12,008
Fire Island Inlet water diluted with distilled water	8,140	16	180	600
Fire Island Inlet water diluted with distilled water	3,905	20	28	240
Great South Bay water south of Nicoll's point	11,980	500	1,200	1,200
Bellport bay	7,495	28	69	52
Connetquot River inlet	1,850	20	5	56

CHEMICAL CONDITION OF THE WATER

On December 9 to 11, 1907, samples of water collected at various points in the Great South bay gave the following figures:

Date	Locality	Parts per Million: Albuminoid Ammonia	Parts per Million: Free Ammonia
December 9	Fire Island inlet	.122	.030
" 11	Opposite Nicoll's point	.168	.074
" 11	Opposite Blue Point	.216	.146
" 11	In Bellport bay	.140	.170
" 11	Mouth of Connetquot river	.106	.116

On November 19 a series of samples was collected from Babylon and Patchogue which gave the following analyses:

Station	Locality	Parts per Million: Albuminoid Ammonia	Parts per Million: Free Ammonia
90	Opposite Babylon	.120	.120
92	Opposite Bayshore	.184	.116
94	West of Nicoll's point	.190	.138
96	Opposite Oakdale	.256	.218
98	Opposite Blue Point	.244	.164
99	Patchogue bay	.220	.146

These results show that the water at the east end of the bay contains considerably more organic matter than the water at the Fire Island inlet, and also that the amount of decomposition going on there is greater.

The figures just quoted are somewhat lower than those obtained by Prof. Bashford Dean at Patchogue in the vicinity of the Blue Point oyster-beds during the summer of 1885.

Physical Condition of the Water of Great South Bay

Many determinations of the turbidity, color and odor of samples of water collected from the Great South bay were made during November and December, 1907. The results have been tabulated and plotted on a map of the bay, Sheet 135, Acc. 5537.

The sea-water entering the bay at the Fire Island inlet is comparatively clear, but in the eastern part of the bay the water is more turbid. The color of the bay water is, as a rule, quite low, but in certain places near the Long Island shore the color is higher. As a rule the water has very little odor, but occasionally samples were taken that had traces of fishy odors and odors suggestive of oysters. Most of these samples were taken from the oyster-beds.

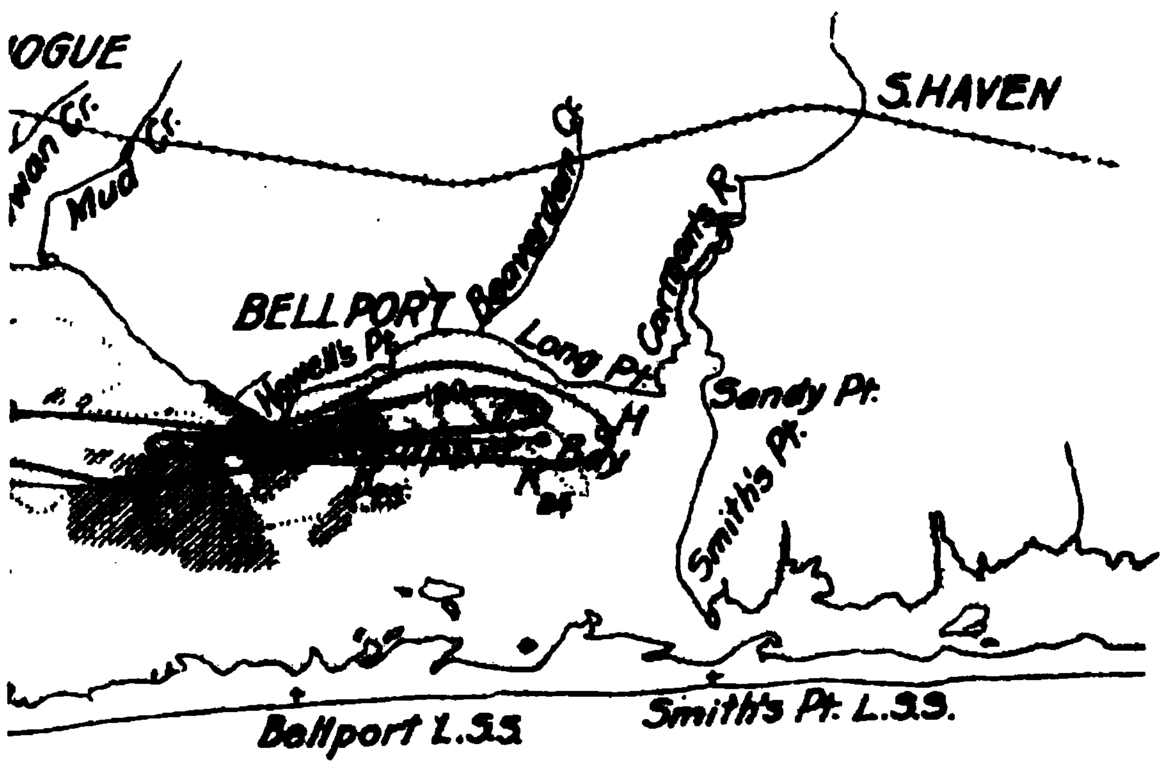
Quality of the Water in the Inflowing Streams
Observations of 1907

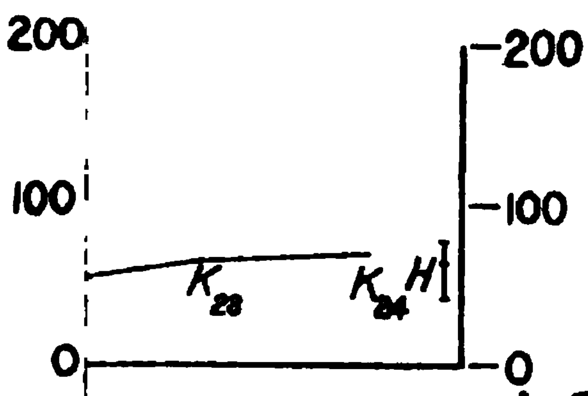
The quality of the surface-water flowing into the Great South bay is shown by the analyses in Table 39. The samples included in this table were collected on January 7, 1908, from 15 of the largest streams that flow into the bay.

The water in these streams varied considerably in character. Some of them were considerably polluted; others only slightly polluted. Generally speaking, the amounts of organic and mineral matter carried by them are comparatively small and considerably less than the amount of organic matter that was found in the water of the bay itself.

The numbers of microscopic organisms in the samples were also small. The most prominent organism was Anthophysa. There were few diatoms in any of the samples.

These streams probably do not differ materially in their microscopic organisms from the streams of the present water-supply of Brooklyn. The following figures based on the analyses of weekly samples show the average numbers of





City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
GREAT SOUTH BAY
DISTRIBUTION OF TURBIDITY

FEBRUARY 24, 1908

Acc. 5537

organisms in the ponds of the Brooklyn system during the years 1897 to 1902:

	Average number of microscopic organisms per cubic centimeter
Massapequa pond	47
Wantagh pond	42
Newbridge pond	21
East Meadows pond....................	33
Millburn pond	28

These figures are not large. Moreover, they represent growths in the reservoirs rather than the organisms in the water of the streams themselves.

The best available data indicate that the organisms in the streams furnish only an insignificant quantity of food supply of the oyster.

Analyses of several of the ground-waters in Suffolk county show that in them, also, the amounts of organic mineral matter are comparatively small. These analyses were given in full in my report to the Commission of Additional Water Supply of New York City in 1903.

During the next 10 or 20 years it may be reasonably expected that the mineral and organic contents of both the ground-water and surface-water entering the Great South bay will be increased for the reason that the population on the watershed is constantly becoming larger. The extension of the residential districts into Nassau county will more and more force the farming interests eastward, and the increase of farming in Suffolk county and the use of larger amounts of fertilizers will materially increase the amount of food material for the microscopic organisms that will be carried into the bay. This natural increase in food material will more than offset any loss by the diversion of ground-water. Furthermore, some of the towns on the watershed already need sewerage systems, and it may be expected that in the near future such systems will be built at several places. In order to properly safeguard the oyster industry in the bay it will be prudent to purify the sewage of such communities before it is allowed to be discharged, but even after purification the

residual amounts of organic matter added to the waters of the bay will tend to stimulate the growth of diatoms. Considering the fact that the diatom crop in the bay is now ample for the needs of the oysters, and considering the natural increase that may be expected in the amount of food material turned into the bay in the near future by reason of increased population on the watershed, there is no reason to fear that the slight deduction of food material entering the bay in the form of springs will be of any practical significance to the oyster industry. The effect of the increasing population on the sanitary conditions is of far greater importance.

Quality of the Water in the Inflowing Streams
Observations of 1908

On September 3, 1908, a trip was made by automobile from Amityville to Bellport, and samples of water collected from all of the important streams flowing into the Great South bay. The results of the analyses of these samples are shown in Table 40. Other samples were also collected from some of the inlets as, for instance, at Bayshore, Islip, Sayville and Patchogue (see Table 41).

The bacteriological analyses bear out the investigation that was made in 1907 and show that many of these streams are more or less polluted with fecal matter. Some of the samples showed the presence of B. coli in quantities of water as small as 0.1 cubic centimeter. The samples from the inlets, in particular, showed contamination, the numbers of bacteria being high and the tests for B. coli indicating the presence of this intestinal germ in comparatively large numbers.

The practice of floating oysters in the inlets is still continued. On the day of the inspection men were seen taking oysters from two floats in the inlet at Bayshore, while on the same day samples of water collected from this inlet showed it to be contaminated.

The samples of water collected from the various streams were also tested for hardness and alkalinity and for the most part the water was found to be extremely soft. In a few cases the analyses showed the alkalinity as higher than the hardness, but these figures are probably in error, the excess being due to alkalinity derived from the bottles used in the collection of the samples. There seems to be no doubt, however, that the alkalinity and hardness are very much the same.

These figures agree substantially with others recently reported and differ from some of the published figures in the report of the Commission on Additional Water Supply, which figures apparently were in error so far as the amount of permanent hardness is concerned. In a few cases, as, for instance, the stream entering east inlet at Bayshore, there may have been some admixture of sea-water, accounting for the high chlorine and for the incrustants, but this sample was considerably polluted and part of the increase was probably due to the pollution. The high chlorine in the stream at West Sayville and at Patchogue were probably also due to the effect of pollution. The chlorine in the Swan river at the South Country road probably was due to an admixture of sea-water. None of the waters of the various inlets can be considered as grossly polluted, but some of them as, for instance, at Bayshore, Islip and Patchogue, are so subject to contamination that oysters ought not to be floated in these waters. The basin at the mouth of the creek at Sayville appears to be fairly satisfactory from the sanitary standpoint, and much better than the waters of the inlets.

Quality of the Oysters in the Great South Bay

Many samples of oysters from different parts of the Great South bay were examined. In general it may be said that the sanitary condition of these oysters was satisfactory. Many samples were tested for B. coli, but the results were, for the most part, negative.

Examinations were made of the contents of the stomach and intestines of the oysters collected. It was found that the diatoms in the stomach corresponded in kind to those found in the water, but the quantitative analyses did not yield results from which any important conclusions could be drawn. These data are therefore omitted from this abridged report.

Natural Advantages of the Great South Bay as an Oyster Ground

The Great South bay is a favorable place for growing oysters for the following reasons:

(1) The specific gravity of the water is favorable over a considerable portion of the area.

(2) The depth is favorable both for oyster growth and for convenience of cultivation and harvesting.

TABLE 40

Results of Analyses of Samples of Water from Various Streams Discharging Into Great South Bay
(Samples Collected by G. C. Whipple on September 3, 1908)

Laboratory No.	Field Mark	Hour of Collection	Place of Collection	Turbidity	Color	Odor	Chlorine	Hardness	Alkalinity	Incrustants	Bacteria per Cubic Centimeter	B. Coli 0.1 Cubic Centimeter	B. Coli 1.0 Cubic Centimeter	B. Coli 10.0 Cubic Centimeters
3201	2	9:10 A.M.	[illegible] oad	no chemical sample							100	+	+	+
3202	3	9 20 A M.	[illegible] k road	2	15	2v	6.0	11	7	4	80	0	+	+
3203	4	9.30 A.M.	[illegible] road	2	18	3v	6.0	8	6	2	360	0	+	+
3204	5	9:40 A M.	Carlls river at Merrick Road outlet of pond	3	18	2v	6.5	3	7	0	235	0	+	+
3205	6	10:30 A.M.	Sampawam's creek at Merrick Road outlet of pond	3	19	1v	8.5	8	7.5	0.5	90	0	+	+
3222	7	...	Willett's creek outlet of pond	1	38	2v	7.0	12	13.5	0	...	.	..	..
3223	8	...	[illegible]	2	16	1v	7.0	8.5	8	0.5	...	..	.	.
3225	13	...	[illegible] yshore	1	16	0	56.5	31	13.5	17.5	.		..	..
3200	14	11.55 A.M.	[illegible]	0	13	0	8.0	6	8.5	0	116	+	+	+
3220	15	...	[illegible] l	0	38	1v	7.0	10	10	0	...		..	.
3211	17	1:35 P.M.	[illegible]	1	11	2v	6.0	3	7	0	125	0	+	+
3212	18	1:40 P.M.	[illegible] ver west of [illegible] uth side of [illegible]	1	15	1v	7.0	12.5	15	0	400	0	0	+
3227	19	...	[illegible] r	2	17	0	8.0	16	16	0	...	.	.	.
3229	22	2:30 P M.	[illegible]	2	12	0	16.5	10.5	17	2.5	.	.	..	.
3230	23	2:40 P.M.	[illegible] outlet of [illegible]	1	9	1v	8.0	12	12	0	..	.	..	.
3231	24	...	[illegible]	2	13	2m	7.0	6	7	0	..	.		..
3232	25	...	[illegible]	2	15	1v	7.0	14.5	13	1.5	...	..	.	.
3214	26	2:55 P.M.	[illegible] ountry road below lace mill	2	17	2v	16.5	14 5	12.5	2.0	23	0	0	+
3235	30	...	Swan river at South Country road	2	15	1v	33.0	19.5	13.0	6.5	..		..	..
3255	.	Sep. 15, 1908	Carman's river	1	9	12	7.0	12.0	14.0	0	...	..	..	..

TABLE 41

RESULTS OF ANALYSES OF SAMPLES OF WATER FROM CERTAIN INLETS AND BASINS ON THE GREAT SOUTH BAY WHERE OYSTERS ARE FLOATED, SEPTEMBER 3, 1908

Laboratory No.	Field Mark	Hour of Collection	Place	Turbidity	Color	Odor	Chlorine	Number of Bacteria per Cubic Centimeter	Test for B. Coli: 0.1 Cubic Centimeter	1.0 Cubic Centimeter	10.0 Cubic Centimeters
			BAYSHORE								
3207	10	11:20 A.M.	Head of west inlet	5	6	1v	7,070	2,000	+	+	+
3206	9	11:10 A.M.	Mouth of west inlet	3	8	1v	12,120	2,600	0	+	+
3208	12	11:35 A.M.	Head of east inlet	3	10	2m	3,838	5,200	+	+	+
			ISLIP								
3210	16	12:10 P.M.	Mouth of creek near oyster houses	3	9	1v	12,020	1,450	+	+	+
			SAYVILLE								
3213	20	2:00 P.M.	West basin, near Rudolph's wharf	3	10	1v	10,810	3,200	0 (Dredging going on)	0	+
3228	21	2:10 P.M.	East basin, near Vanderberg's wharf	2	15	1v	10,700	......	..	..	..
			PATCHOGUE								
3215	27	3:00 P.M.	Creek at railroad crossing	3	13	3v	1,210	480	0	+	+
3233	28	3:15 P.M.	Head of inlet	3	14	1v	9,495	......	..	..	..
3234	29	3:17 P.M.	Bay, opposite Nassau Oyster Company	2	12	1m	9,695	......	..	..	..

TABLE 42

Results of Chemical Analyses of Samples of Water Collected at Various Places in the Great South Bay, September 3 and 4, 1908

Laboratory No.	Field No.	Date of Collection	Hour of Collection	Place	Temperature Degrees	Depth	Turbidity	Color	Odor*	Chlorine	Free Ammonia	Nitrogen as Albuminoid Ammonia	Nitrogen as Nitrites
3244	1	Sep 3	8 33 A M.	½ mile off Babylon dock	69.5	Surface	12	14	2f oysters	16,100	.154	.260	.002
3237	2	" "	8:52 A M.		68.0	"	8	12	1v	15,600	.118	190	.002
3238	3	" "	9:15 A.M.		69.5	"	4	12	2m	15 200	.128	.192	.002
3239	4	" "	10 20 A M.		68.0	"	9	10	2v	14 900	.122	250	.005
3240	5	" "	11 02 A M.		69.0	"	4	12	2v	13 200	.142	.176	005
3241	6	" "	12 00 M.		68 5	"	2	12	2v	14 300	.136	236	.002
3242	7	" "	12 35 P M.		68 3	"	6	11	1v	14 200	.244	.250	.012
3243	8	" "	1:05 P.M.		68 0	"	4	11	1v	15 300	.148	.234	.007
3245	2	Sep. 4	10:05 A.M	¼ mile off Blue Point	69.0	"	3	11	2f oysters	11,600	.288	.246	.002
3246	3	" "	11.33 A M.	¼ mile off Green's point	69.0	"	4	11	1v	12,400	.180	.254	.002
3247	4	" "	12:05 P.M.	1½ miles off Lone hill	69.5	"	2	12	2f oysters	13,200	.154	.278	.003
3248	5	" "	12:53 P M.	¾ mile off Blue Point Life saving station	69.0	"	2	10	2f oysters	13,200	.144	.306	.002
3249	6	" "	1:30 P M.	Middle Patchogue	69.6	"	3	11		11,900		Broken	
3250	7	" "	2:05 P.M.	¼ mile off Howell's point	70.0	"	4	10	2f oysters	10,000	.170	.308	.007

*1 very faint 2 faint v vegetable m moldy f fishy

(3) The bottom in the main channel is generally clean and hard.

(4) The food supply is ample. This may be considered as being due partly to the inflow of fresh water, partly to the comparative shallow depth of the bay which tends to increase the temperature of the water during the summer season, and thereby favor diatom growth, partly to the existence of large areas of mud flats suitable for diatom development, and partly to the land-locked character of the bay which tends to prevent a rapid interchange of water, thus holding in the bay a large percentage of the diatoms that grow there.

(5) The currents in the main channels where the oyster beds are located are ample to supply the oysters with food, to prevent fouling of the water at the bottom by silting, and to prevent stagnation.

(6) The bay is comparatively free from the depredations of starfish and other enemies that are essentially of a salt-water character.

(7) The bay is comparatively free from contamination.

(8) The location of the area is favorable with respect to the New York market.

Natural Changes that May Take Place in the Bay

It has already been remarked that the sand-bars that enclose the beds on the south shore of Long Island are not permanent. It is not at all impossible that breaks caused by natural agencies through the bar may occur at one or more points some time in the future. The present conditions are by no means assured of permanency. Already within the last few years considerable changes have taken place at Fire Island inlet. Should a break occur in the sand-bar in the vicinity of Blue Point or at some other point east of that, there would be a marked increase in the salinity of the water at the east end. This would have a generally favorable effect upon the oyster culture in that section. Prof. Bashford Dean, in his report to the New York Commission of Fisheries in 1886, apparently appreciated the advantage that would accrue if the water in this section of the bay were more saline, for he states that " the saltness of the water must, however, be taken into consideration. It would seem that the enormous facilities for oyster feeding are in some way counter-balanced by the deficiency in the saltness of the water and it can hardly be ques-

tioned that with a slightly increased saltness of the water, with a specific gravity of 1.016 instead of 1.012, the remarkable fresh-water resources of the bay would make it the most efficient of our state oyster grounds."

It is said that the general tidal level of the sea-water in the vicinity of New York is rising with respect to the land at the rate of something less than one foot in a century. If this is true it may be expected that there will be a natural increase of the saltness of the water in the bay as time goes on. This may not be an important matter, but certainly the tendency would be in that direction. In Bashford Dean's report there is given a table of specific gravities of the water over the oyster-beds in the vicinity of Blue Point near Patchogue. Weekly observations were made from July 20 to September 16 which showed that the specific gravity at that time averaged about 1.011. Variations, however, were noted from 1.009 to 1.014. According to the recent determinations the specific gravity of the water in the same section has been very slightly higher than it was in 1886.

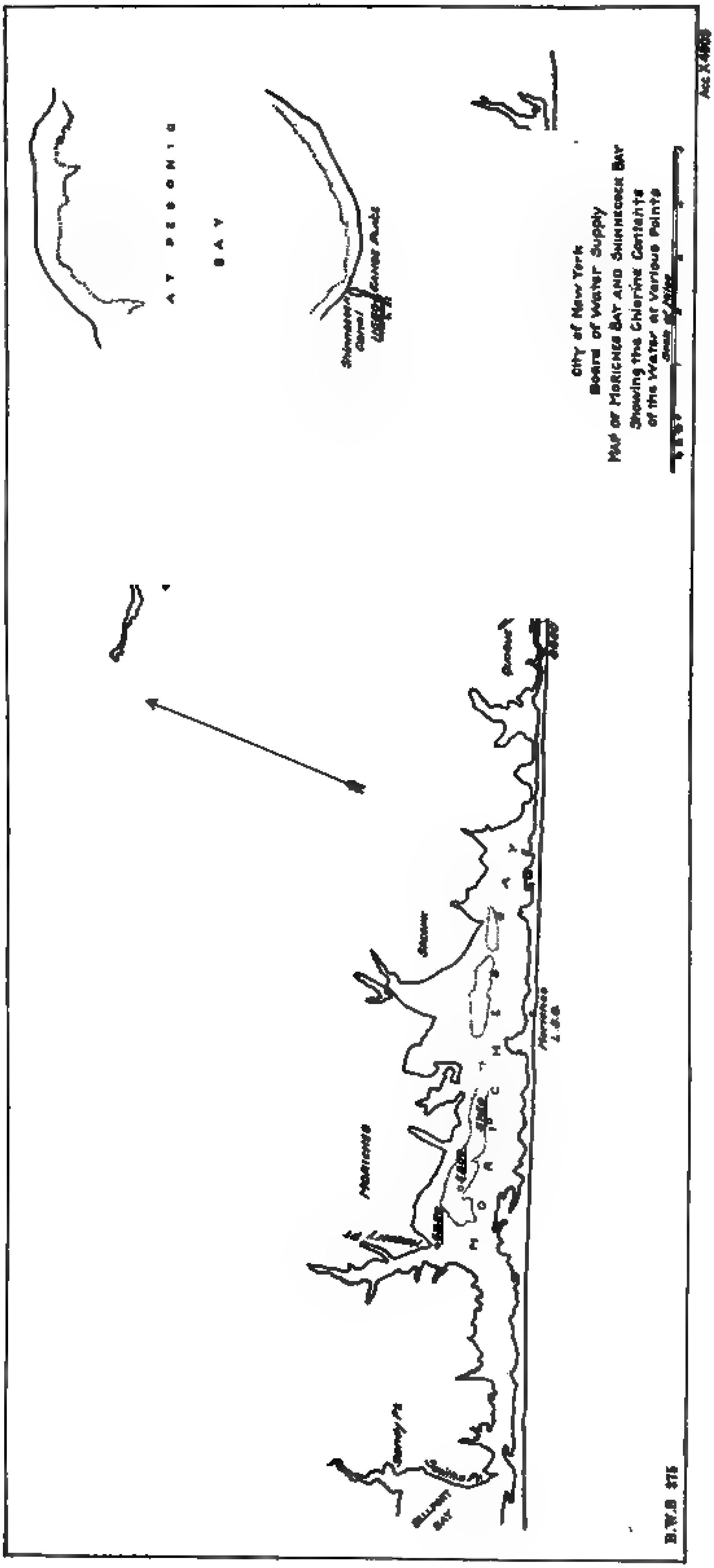
Natural changes may take place also in the amount of fresh water entering the bay. These changes will depend upon the rainfall. Periods of drought may be succeeded by periods of heavy rainfall and these changes must inevitably cause material difference in the salinity of the water of the bay.

Winds and storms are also likely to cause alterations on the deposits over the bottom of the bay, changes in currents may cause relocations of sand-bars, whole channels may become filled up and new channels may be opened, sandy areas now used for oyster cultures may become foul with mud, while other areas may be scoured.

These and many other changes are bound to influence the growth of oysters in the bay. Many of them are of such an uncertain character that they cannot be reckoned with. These natural changes will doubtless damage some beds and benefit others.

MORICHES BAY

Oysters are not commercially grown in Moriches bay as the water there is too fresh. On December 7, 1907, three samples of water were collected at various points in the western half of the bay, but were found to contain chlorine to the extent of only 5250 to 5800 parts per million. The water


City of New York
Board of Water Supply
Map of Moriches Bay and Shinnecock Bay
Showing the Chlorine Contents
of the Water at Various Points
Peconic Bay
Moriches Bay
Moriches
B.W.S. 315

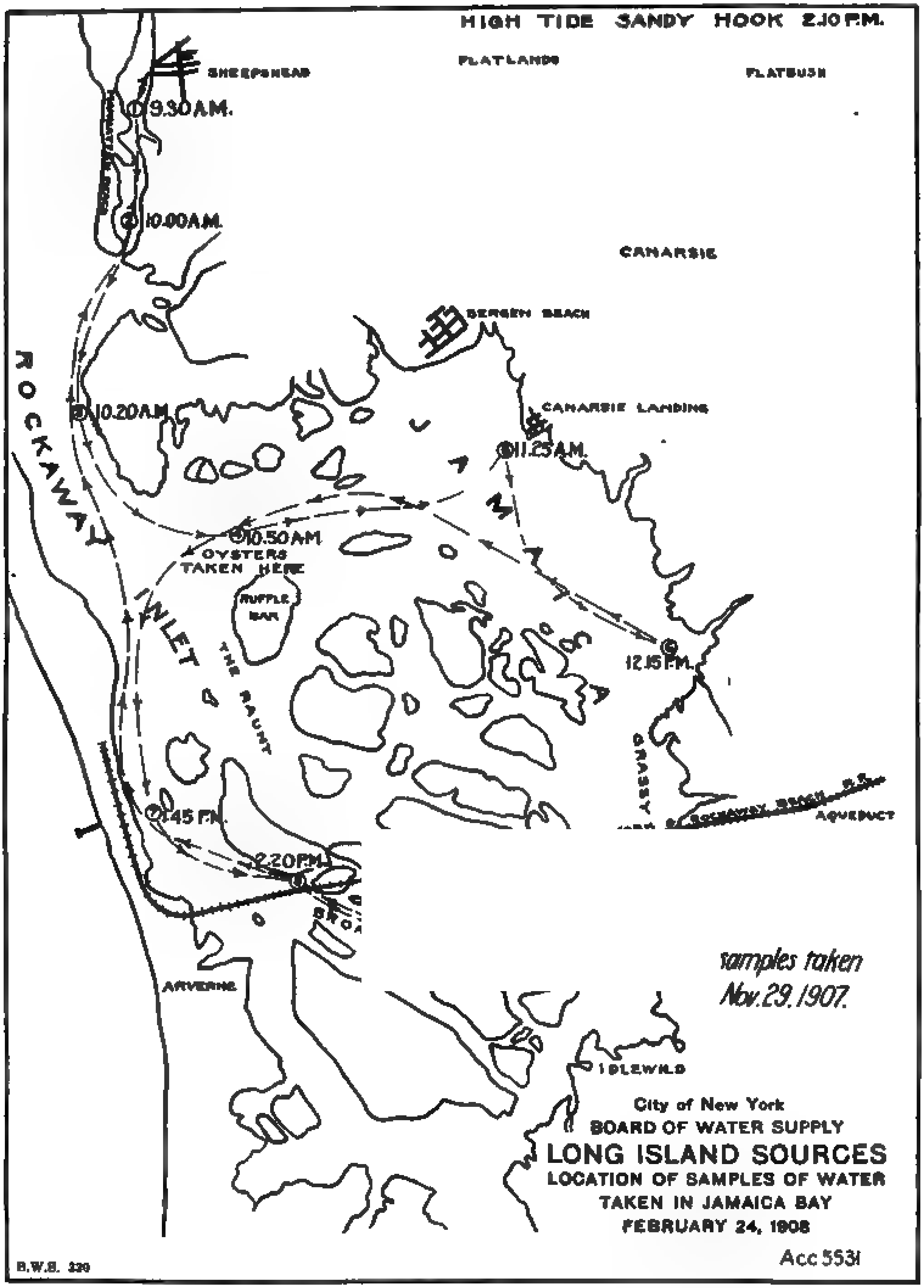
at this point is, therefore, made up of about two-thirds fresh water and one-third sea-water. Moriches bay is not used for oyster culture on account of its lack of salinity, but it is said that projects have been considered for cutting an opening through Fire island in order to admit salt water and thus make it possible to use this bay for oyster culture. It is unlikely, however, that this would be a profitable undertaking on account of the shallowness of the water over the greater part of the bay. (Sheet 136, Acc. X 4909).

SHINNECOCK BAY

Until within a comparatively recent period the waters of Shinnecock bay were too fresh for growing oysters commercially, but since the construction of the Shinnecock canal it is said that there has been an increase in the salinity of the water in the eastern part of the bay, and the industry is now fairly productive. There is no natural connection of Shinnecock bay with the ocean on the south side, but canals have been cut through the sand-bar in order to increase the salinity of the water. These have a tendency to fill up with sand and are not permanent.

On December 18 and again on December 24, samples of water were collected at various points in Shinnecock bay from its westerly end to its outlet in the Shinnecock canal. The chlorine in these samples varied from 8650 parts per million at the westerly end to 11,500 parts per million in the Shinnecock canal. Throughout the greater part of the bay the chlorine was about 10,500 parts per million. The water here, therefore, contained about 60 per cent. of sea-water and 40 per cent. of fresh water.

On December 27, 1907, a series of samples of oysters was received from the easterly end of Shinnecock bay. All of these samples gave negative tests for the colon bacillus. They were all of fair quality, but the flesh was somewhat soft and dark colored. The chlorines ran between 10,000 and 11,000 parts per million. On the whole, these oysters were not quite as attractive as the average run of oysters of similar size found in the Great South bay.


HIGH TIDE SANDY HOOK 2.10 P.M.
FLATLANDS
FLATBUSH
SHEEPSHEAD
9.30 A.M.
10.00 A.M.
CANARSIE
BERGEN BEACH
CANARSIE LANDING
10.20 A.M.
11.25 A.M.
ROCKAWAY INLET
10.50 A.M.
OYSTERS TAKEN HERE
RUFFLE BAR
THE RAUNT
12.15 P.M.
GRASSY
AQUEDUCT
1.45 P.M.
2.20 P.M.
ARVERNE
IDLEWILD
samples taken
Nov. 29. 1907.
City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
LOCATION OF SAMPLES OF WATER
TAKEN IN JAMAICA BAY
FEBRUARY 24, 1908
Acc 5531
B.W.S. 330

On the same date samples of water were collected and analyzed for chlorine, with the following results:

ANALYSES OF WATER FROM SHINNECOCK BAY

Laboratory No.	Marked	Chlorine Parts per Million
574	200 feet east of Quogue bridge, middle of channel. December 18, 1907, 10.00 A.M. (1)	8,650
575	Shinnecock bay ¼ mile east of Quogue bridge, middle of channel. December 18, 1907, 10:15 A.M. (2)	10,100
576	Shinnecock bay, 800 feet southeast off-shore over oyster-beds. December 18, 1907, 10:40 A.M. (3)	10,400
577	Shinnecock bay, 1,200 feet southeast off-shore over oyster-beds. December 18, 1907, 10:55 A.M. (4)	10,550
578	Shinnecock bay, channel off Shinnecock, Long Island station. December 18, 1907, 12:05 P.M.	10,650
580	Bridge, Canoe place, taken December 24, 1907, 9:45 A.M. Shinnecock canal. J. W. Linney, Collector	11,550
581	Shinnecock bay, off Cormorant point in channel. December 24, 1907, 11:30 A.M. J. W. Linney, Collector	11,300
582	Shinnecock bay, off Ponquogue point in channel. December 27, 1907, 10:30 A.M.	10,950

JAMAICA BAY

The oyster industry in Jamaica bay is quite large. Conditions there are said to be very favorable for the growth of oysters, although they are objectionable from a sanitary standpoint. On November 29, 1907, a series of samples was collected in Jamaica bay, the results of which are given in tables following. Comparison of the chemical analysis of the water with that of the Great South bay will show that while the amount of albuminoid ammonia is not greatly different, the amount of free ammonia is very much higher.

On November 29, 1907, samples of oysters were obtained from Jamaica bay at a point a short distance southwest of Ruffle bar. Out of six samples tested for B. coli two gave positive results in one cubic centimeter of the oyster liquor, indicating that the water at that point was not free from contamination. Aside from this unsatisfactory sanitary showing, the oysters were of fair quality. The chlorine in the oyster liquor was about 15,000 parts per million. The locations of the samples are shown on Sheet 137, Acc. 5531, and the results of the analyses were as follows:

RESULTS OF ANALYSIS OF SAMPLES OF WATER FROM JAMAICA BAY, LONG ISLAND

COLLECTED ON NOVEMBER 29, 1907, BY C. M. EVERETT

Number of Station	Hour of Collection*	Depth of Sample	Chlorine Parts per Million	Turbidity	Color	Diatoms per Cubic Centimeter	B. Coli in One Cubic Centimeter of Water	Remarks
1**	9:30 A.M.	0.0	14,420	15	11	33		
1	9:30 "	3.5	14,870	15	8	42		
2**	10:00 "	0.0	14,670	8	7	21		
2	10:00 "	10.0	14,970	5	7	26		
3	10:20 "	0.0	14,970	6	17	31		
3	10:20 "	22.0	15,070	4	12	18		
4	10:50 "	0.0	14,970	4	9	18		
4	10:50 "	4.0	15,070	4	8	38		
5	11:25 "	0.0	14,120	3	10	8	+	Ca as $CaCO_3$ = 771
5	11:25 "	10.0	14,220	4	9	6		
6	12:15 P.M.	0.0	13,650	4	13	9		
6	12:15 "	10.0	13,475	3	9	19		
7	1:45 "	0.0	15,270	4	6	15		
7	1:45 "	15.0	15,170	4	7	35		
8	2:20 "	0.0	14,720	3	15	45		
8	2:20 "	15.0	14,720	4	7	56		
9	2:50 "	0.0	13,825	5	7	24		
9	2:50 "	5.0	13,975	5	6	21		

*High tide at Sandy Hook at 2:10 P.M.
**Samples 1 and 2 were collected in Sheepshead bay

DESCRIPTION OF SAMPLE

Laboratory number	2761	2765
Source of sample		
Jamaica bay	Station 5	-
Date of collection	November 29, 1907	

CHEMICAL ANALYSIS

Nitrogen as		
Albuminoid ammonia	.182	.196
Free ammonia	.816	.664
Nitrites	.080	.080
Calcium carbonate	771.000	

BACTERIOLOGICAL ANALYSIS

Number of bacteria per cubic centimeter	8	6

APPENDIX 13

AGRICULTURAL INTERESTS OF SUFFOLK COUNTY AND EFFECT ON THEM OF PROPOSED DIVERSION OF GROUND-WATER TO NEW YORK CITY

BY WALTER E. SPEAR, DIVISION ENGINEER

Agriculture has been one of the leading industries on Long Island since its settlement, and to-day truck farming, to which agricultural activity is to a great extent confined, is of the first importance. The industry is practiced most extensively in Queens and Nassau counties, although large areas in Suffolk county are devoted to truck gardening and general farming. The menace to the prospective agricultural interests in Suffolk county, which the farmers there mistakenly see in the proposed diversion of the surplus ground-waters to New York City, has apparently been one of the principal obstacles to the acquirement of this much needed supply for Brooklyn borough. A full understanding of the movement of the ground-waters in these Long Island soils, and an appreciation of the means by which the moisture needs of vegetation are supplied, are sufficient to show the falsity of the position taken by the agricultural interests of Suffolk county.

The success of agricultural operations, in quite all of the farming districts in Long Island, is entirely dependent upon the amount and distribution of the rainfall, the character of the soil and the means taken to conserve the rains in the surface strata. With the exception of small areas here and there in Suffolk county, as well as in Nassau and Queens, the growing crops, shrubs, trees and other vegetation cannot draw upon the ground-water after it once passes the surface soils and percolates downward to the main water-table. It makes little difference therefore in the success of agricultural operations, where the surface of the ground-water is when the vegetation cannot normally draw upon it, and it will be shown that outside of a few areas representing but a small percentage of Suffolk county, farming would not be affected by any movement of the water-table that might result from the proposed diversion of water to New York City.

CHARACTER AND DISTRIBUTION OF LONG ISLAND SOILS

The Bureau of Soils, U. S. Department of Agriculture, in the Report of 1903 (" Soil Survey of the Long Island Area, New York," by Jay A. Bonsteel and Party), recognizes 15 types of soils on Long Island in that portion covered by their surveys west of Patchogue and Port Jefferson. These 15 types of soils are, for convenience of discussion, separated in the table following into three great divisions—the moraine soils, the plains soils and the marsh soils. The location and relative areas of these soils are shown on Sheet 148, Acc. L 646, which has been made up from the maps accompanying the above report of the Bureau of Soils.

CHARACTER OF LONG ISLAND SOILS
FROM REPORT OF BUREAU OF SOILS, 1903

Soil	Per Cent. of Whole Area Covered by this Soil	General Depth of Top-soil in Inches	General Depth of Subsoil in Inches	Adaptability of this Soil for Agriculture
		MORAINE SOILS		
Miami stony loam	9.6	8	24	General farming
Alton stony loam	18.6	6	36	Late truck farming
Plainwell stony loam	1.0	6	None	Of little value
		PLAINS SOILS		
Sassafras gravelly loam	17.5	8	24	Truck farming
Norfolk coarse sandy loam	12.0	8	24	Late truck and general farming. Unreliable
Norfolk sand	14.2	12	24	Early truck farming
Norfolk gravel	0.6	None	None	Useless
Norfolk coarse sand	0.3	None	None	Useless without irrigation
Meadow	3.1	..	..	Truck farming if drained
Hempstead gravelly loam	3.6	8	24	Truck farming
Hempstead loam	6.4	8	24	Truck farming
Sassafras sandy loam	1.0	12	36	Truck farming
		MARSH SOILS		
Galveston sandy loam	3.0	12	..	Truck farming with drainage
Galveston sand	2.3	None	None	Worthless
Galveston clay	6.7	24	None	Truck farming after reclamation

Moraine Soils

The stony loams that cover the morainal ridges in the northerly portion of the island are generally fine, are retentive of moisture and of considerable depth, and are underlain with semi-impervious beds of clay and till. Fruits, grains, grasses and deep rooted crops grow well in these districts. Being

favorable for general farming, they have been cultivated to a greater extent than the larger areas of sandy soils in the broad level plains of central and southern Suffolk county. Where not occupied by farms, these moraine soils support hardwood forests of oak and chestnut. The Miami stony loam is by far the best of these moraine soils. The Alton stony loam is sandier and more nearly resembles some of the plains soils. The Plainwell loam is still coarser and less suited to agricultural purposes.

The moraine soils are confined in Suffolk county to a few small areas on the summits of the southerly moraine and to the northerly morainal ridge outside of the limits of the catchment area of the proposed supply. These moraine soils within the catchment area are at so great a distance from the location of the proposed collecting works, so far above the main water-table and so separated from this water-table by impervious strata, that there is no possibility that their moisture condition could be affected by any movement in the water-table along the south shore. They are, therefore, of no interest in the present discussion.

Plains Soils

The soils found by the Bureau of Soils in the inter-morainal valleys and the broad southerly sloping plains of Suffolk county are the Sassafras gravelly loam, Norfolk coarse sandy loam, Norfolk sand, Norfolk gravel, Norfolk coarse sand, and the meadow soils.

The Sassafras gravelly loam occurs in the northerly portion of the outwash plains near and even on the lower slopes of the moraines. This is a yellow loam with gravel and some of the fine clayey material that characterizes the moraine soils. The Sassafras gravelly loam grades off toward the south into the sandier Norfolk coarse sandy loam and the Norfolk sand of the south shore.

These plains soils are open, well underdrained by the coarse sands and gravels beneath them and are admirably adapted for early truck gardening. They are cultivated extensively in western Long Island, but in Suffolk county only the Sassafras gravelly loam in the central part of the island, and the Norfolk sand along the south shore and in some of the large valleys have been cultivated. The relatively small areas of Suffolk county occupied by farms are shown on Sheet 149, Acc. 5334, which is the result of surveys of the Long Island department

during the past year. Outside of these small areas of cultivation, the plains of Suffolk county are covered with sproutland and forests of low scrub oak and pitch pine. These trees live during periods of drought with but little moisture and are able to resist the forest fires that frequently sweep over the interior of the island. These fires have prevented the accumulation of humus, and as a result the plains soils are generally thin and leachy and allow the rains to percolate rapidly through them. By supplying to the better soils the necessary vegetable matter and making them alkaline by turning in lime or wood ashes, they become an admirable soil, if properly cultivated during the growing season, to conserve the moisture that falls upon them.

The Norfolk coarse sand and Norfolk gravel are worthless for agricultural purposes and the thin, stunted forests that cover them in some localities represent the limit of their capabilities.

The Hempstead loam and the Hempstead gravelly loam are important soils for general farming and truck gardening, but are found only in Nassau and Queens counties. The Hempstead loams are of finer texture and more retentive of moisture than the Sassafras loams that are similarly situated in the outwash plains in Suffolk county. The Sassafras sandy loam occurs only in a small area in Kings county.

The meadow soils of Suffolk county are of little value without extensive drainage. The proposed ground-water collecting works would provide this to small portions of the meadow lands near the works and substantial benefit would accrue to them, that would go far towards offsetting the small injury that might be done to crops on adjacent lands slightly above the surface of saturation.

Marsh Soils

The marsh soils of the south shore of Long Island can only be made available by extensive reclamation and need not be considered in this report. Of these the Galveston sands of the sea beaches are, of course, worthless for agriculture.

Comparison of Soils in Suffolk, Nassau, Queens and Kings Counties

The report of the Bureau of Soils indicates that the soils are, on the whole, better in Kings, Queens and Nassau coun-

ties than in Suffolk county. Doubtless, years of cultivation have had something to do with this result, but it should be noted that a greater proportion of western Long Island is within the moraines and is covered with moraine soils and allied types of finer texture than are found in Suffolk county, where the areas of moraine are relatively smaller, and a large part of the southerly outwash plains is far from the clays and other fine material in the moraines.

While large areas of land in Suffolk county now covered with scrub oak and pine can be readily cultivated with success, much of the soil in these barren outwash plains, back from the south shore, in the interior of the island would require treatment beyond the means of the ordinary farmer. These soils will doubtless continue for many years to find their best use as sources of fire wood and the areas covered by them as game preserves.

The soil map, Sheet 148, Acc. L 646, shows that the proposed location of the Suffolk County ground-water collecting works lies in the least valuable soil belt in Suffolk county, between the zone of cultivation in the Norfolk sands of the south shore and the better soils near the moraines.

PHYSICS OF LONG ISLAND SOILS

Depth of Soil

The general depth of the loam and subsoil of the several types of Long Island soils are shown in table on page 521 of this report, as reported by the Bureau of Soils. The brown or dark yellow surface loams or top-soils in the outwash plains vary in thickness from 6 to 12 inches, the yellow subsoils beneath, which contain less organic matter, although often as fine as the top-soils, from 24 to 36 inches. The total depth of the soil averages about 30 inches. Beneath the subsoils are the coarse yellow sands and gravels 80 to 200 feet in depth.

The roots of vegetation, even the tap roots of trees, generally find no food nor moisture in the coarse gravel substrata of the outwash plains, and do not penetrate much below the bottom of the yellow subsoil. The average limit of root penetration in the outwash plains is placed at 30 inches, the average depth of the soils.

The Report of the Bureau of Soils states, on page 97:

"Throughout the extent of both belts of plains the combined depth of soil and subsoil is less than 36 inches; usually it does not exceed 24 inches. At such depths it is underlain by a definite band of closely packed gravel or cobbles, which separates it from the coarse porous sands and gravels below. As a result, the total feeding range of crops is limited to a root development in a scant 30 inches of soil. Even those trees which normally develop tap roots have been forced to a shallow feeding system, for in few cases have any forms of vegetation been able to penetrate the gravel. The shallowness of the soil mass affects the growth of the crops in two ways. It limits root development to horizontal spreading, and this results in crowding among closely planted crops of long growth, like grain and grass. It also introduces another element of the same character in limiting the storage reservoir for the maintenance of moisture. Both effects tend toward low crop yields."

The small depth of root penetration is most important, because the roots cannot go beyond the shallow subsoils for water, and it will be shown that capillary moisture rises through but a small hight in the coarse sand and gravel substrata that bar the downward movement of the roots.

Texture of Soils

Some idea of the texture of the surface soils and substrata in Long Island are shown on Table 43, which has been compiled from the test-pits and borings in Appendix VII of the Burr-Hering-Freeman Report, pages 856 to 886, and from analyses of samples obtained during the past year in southern Suffolk county.

The locations of these samples are shown on Sheet 148, Acc. L 646. They cannot be considered as strictly representative of the soil areas in which they are situated, for with the exception of the recent test-pits, these samples come from test-holes and wells that were located for the purpose of surveying the water-table, regardless of the surface soils.

The soils and subsoils are generally too fine to allow their effective sizes to be determined by the ordinary mechanical process of sifting. These are compared in this table by the diameter in millimeters than which 60 per cent. is finer.

TABLE 43

Texture of Long Island Soils

Sample No.	Depth of Sample Below Surface in Feet From	To	Thickness in Inches	Description of Material	Effective Size	60 Per Cent. Finer Than	Uniformity Coefficient
				Miami Stony Loam			
				Well 662, near Corona			
1	0.0	0.5	6	Loam	.....	0.70	.....
2	0.5	1.0	6	Loam and superfine sand	.....	0.14	.....
3	1.0	6.0	60	Coarse and superfine sand	.....	1.30	.....
4	6.0	10.0	48	Fine gravel and superfine sand	0.18	.....	23.20
5	10.0	15.0	60	Medium coarse sand	0.22	.....	6.21
				Well 687, North Jamaica			
1	0.0	0.4	5	Loam	.....	0.220	.....
2	0.4	1.5	13	Loam and superfine sand	.....	0.260	.....
3	1.5	10.0	102	Fine sand	.....	0.435	.....
4	10.0	15.0	60	Medium sand and rock flour	0.172	.....	4.65
				Well 828, Long Island City			
1	0.0	2.0	24	Loam	.....	0.13	.....
2	2.0	5.0	36	Fine and superfine sand	.....	0.11	.....
3	5.0	8.5	42	Fine gravel and medium sand	.....	0.60	.....
4	8.5	15.0	78	Coarse sand	0.18	.....	3.85
				Well 859, Astoria			
1	0.0	2.0	24	Loam	.....	0.13	.....
2	2.0	5.0	36	Superfine sand	.....	0.17	.....
3	5.0	9.5	54	Medium sand	0.18	.....	3.44
4	9.5	12.5	36	Coarse sand	0.23	.....	6.22
5	12.5	14.5	24	Clay	All material in this sample is more than 60 per cent. finer than 1.10 millimeters		
6	14.5	15.0	6	Pebbles	.....	.....	.....
				Well 864, near Lake Success			
1	0.0	0.5	6	Loam	.....	0.22	.....
2	0.5	8.0	90	Fine gravel and fine sand	.....	0.36	.....
3	8.0	14.0	72	Medium sand	0.14	.....	3.00
4	14.0	19.0	50	Medium sand and cobbles	0.13	.....	2.70
				Well 1090, East of Flushing			
1	0.0	2.0	24	Loam	.....	0.11	.....
2	2.0	5.0	36	"	.....	0.10	.....
3	5.0	10.0	60	Fine gravel and fine sand	0.13	.....	4.04
4	10.0	15.0	60	Coarse and fine sand	0.20	.....	2.80
				Alton Stony Loam			
				Well 695, Northwest Jamaica			
1	0.0	1.5	18	Loam	.....	0.255	.....
2	1.5	5.0	42	Subsoil	.....	0.280	.....
3	5.0	10.0	60	Coarse and medium sand	0.221	.....	4.12
4	10.0	15.0	60	Fine gravel and fine sand	0.208	.....	3.66
				Well 956, North Lake Success			
1	0.0	1.0	12	Loam	.....	0.110	.....
2	1.0	4.0	36	Loam	.....	0.345	.....
3	4.0	9.0	60	Medium sand, rock flour, little clay	0.130	.....	3.35
4	9.0	14.0	60	Coarse and medium sand	0.150	.....	3.00
5	14.0	15.0	12	Fine gravel and coarse sand	0.225	.....	3.82

TABLE 43 (*Continued*)

Sample No.	Depth of Sample Below Surface in Feet: From	To	Thickness in Inches	Description of Material	Effective Size	60 Per Cent. Finer Than	Uniformity Coefficient
				Sassafras Gravelly Loam			
				Well 607, Floral Park			
1	0.0	0.5	6	Loam	.....	0.442	.....
2	0.5	1.0	6	Fine sand	0.215	.....	2.68
3	1.0	10.0	108	Medium sand and fine gravel	0.229	.....	5.07
4	10.0	15.0	60	Medium sand and fine gravel	0.221	.....	2.35
				Well 616, Millburn Reservoir			
1	0.0	1.8	22	Loam	.....	0.305	.....
2	1.8	2.3	6	Fine sand and subsoil	.....	0.25	.....
3	2.3	5.0	32	Coarse sand and fine gravel	0.350	.....	3.57
4	5.0	8.0	36	Fine gravel and coarse sand (little fine sand)	0.346	.....	4.05
5	8.0	10.0	24	Coarse and medium sand	0.260	.....	2.77
6	10.0	15.0	60	Coarse gravel and medium sand	0.220	.....	2.41
				Well 619, Creedmore			
1	0.0	1.0	12	Loam	.....	0.168	.....
2	1.0	5.0	48	Subsoil	.....	0.22	.....
3	5.0	9.5	54	Coarse gravel and medium sand	0.262	.....	17.18
4	9.5	15.0	66	Medium sand	0.260	.....	2.27
				Well 717, Northeast Jamaica			
1	0.0	0.4	5	Loam	0.119	.....	3.53
2	0.4	1.0	7	Loam and fine sand	.....	.....	.....
3	1.0	10.0	108	Fine sand	0.238	.....	2.15
4	10.0	15.0	60	Medium sand	0.220	.....	2.50
				Well 845, East Hempstead Reservoir			
1	0.0	1.3	16	Loam	.....	0.225	.....
2	1.3	2.0	8	Coarse gravel and fine sand	0.410	.....	15.24
3	2.0	6.0	48	Fine gravel and medium sand	0.415	.....	6.14
4	6.0	11.0	60	Medium sand	0.289	.....	2.01
5	11.0	15.0	48	Fine gravel and coarse sand	0.225	.....	3.02
				Well 846, Hempstead Reservoir			
1	0.0	1.2	14	Coarse gravel and loam	.....	0.63	.....
2	1.2	2.5	16	Superfine sand and clay	.....	0.30	.....
3	2.5	5.4	35	Fine gravel and coarse sand	0.380	.....	3.74
4	5.4	9.5	49	Coarse gravel, medium sand, little rock flour	0.220	.....	4.09
5	9.5	14.5	60	Coarse sand	0.256	.....	3.28
6	14.5	15.	6	Fine gravel and coarse sand	0.205	.....	2.63
				Well 847, North Hempstead Reservoir			
1	0.0	1.5	18	Loam and coarse gravel	.....	1.38	.....
2	1.5	3.0	18	Coarse gravel and fine sand	0.290	.....	12.76
3	3.0	8.0	60	Fine gravel and medium sand	0.450	.....	11.10
4	8.0	10.0	24	Coarse sand	.223	.....	2.24
5	10.0	12.0	24	Coarse sand	.228	.....	2.63
6	12.0	15.0	36	Fine gravel and medium sand	0.410	.....	12.70
				Well 849, Massapequa			
1	0.0	0.3	4	Loam	.....	0.41	.....
2	0.3	2.4	25	Coarse and superfine sand	.....	0.605	.....
3	2.4	10.0	91	Coarse gravel and medium sand	0.239	.....	7.66
4	10.0	12.0	24	Fine gravel and medium sand	0.270	.....	3.89
5	12.0	15.0	36	Fine gravel and medium sand	0.270	.....	3.89
				Well 858, North Seaford			
1	0.0	0.7	9	Loam	.....	0.875	.....
2	0.7	1.2	6	Medium sand and coarse gravel	0.360	.....	13.90
3	1.2	9.5	99	Coarse sand and fine gravel	0.231	.....	4.16
4	9.5	15.0	66	Coarse and medium sand	0.229	.....	2.53

TABLE 43 (*Continued*)

Sample No.	Depth of Sample Below Surface in Feet: From	To	Thickness in Inches	Description of Material	Effective Size	60 Per Cent. Finer Than	Uniformity Coefficient
				Norfolk Coarse Sandy Loam			
				TEST-PIT "A," NORTHWEST BABYLON			
1	0.0	0.7	8	Loam........................	.056	.....	7.58
2	0.8	1.9	13	Subsoil........................	.048	.....	9.63
3	1.9	2.8	11	"	.038	.....	9.67
4	2.8	3.4	7	Sand........................	.26	.....	1.52
5	3.4	4.1	8	"	.33	.....	3.24
6	4.2	5.1	11	"	.165	.....	2.21
7	5.1	6.0	11	Sand and gravel................	.250	.....	2.76
				WELL 729, SOUTHEAST FARMINGDALE			
1	0.0	0.5	6	Loam........................	.....	1.13	.....
2	0.5	1.0	6	Fine gravel and subsoil..........	.....	0.80	.....
3	1.0	5.0	48	Fine gravel and medium sand....	0.308	.....	8.08
4	5.0	10.0	60	Fine gravel and medium sand....	0.358	.....	8.10
5	10.0	15.0	60	Fine gravel and coarse sand......	0.435	.....	7.13
				WELL 743, NORTH AMITYVILLE			
1	0.0	0.5	6	Loam........................	.....	0.605	.....
2	0.5	1.0	6	Fine gravel and subsoil..........	.....	2.00	.....
3	1.0	5.0	48	Coarse and fine gravel and superfine sand..................	0.530	.....	6.51
4	5.0	10.0	60	Fine gravel and fine sand........	0.380	.....	7.37
5	10.0	15.0	60	Fine gravel and medium sand....	0.341	.....	7.68
				WELL 826, NORTH AMITYVILLE			
1	0.0	0.5	6	Loam and fine sand............	.....	0.74	.....
2	0.5	5.0	54	Medium sand and fine gravel....	0.156	.....	6.73
3	5.0	10.0	60	Fine gravel and coarse sand......	0.259	.....	4.02
4	10.0	15.0	60	Fine gravel and coarse sand......	0.434	.....	4.61
				WELL 843, NORTH OF BAYSHORE			
1	0.0	1.5	18	Loam........................	.....	0.46	.....
2	1.5	5.0	42	Subsoil, coarse and fine gravel....	.....	0.65	.....
3	5.0	10.0	60	Coarse gravel and medium sand..	0.22	.....	4.64
4	10.0	15.0	60	Coarse and fine gravel..........	1.27	.....	1.73
				WELL 861, SOUTH OF BRENTWOOD			
1	0.0	1.0	12	Loam........................	.....	0.50	.....
2	1.0	5.0	48	Coarse gravel and subsoil........	.....	0.39	.....
3	5.0	10.0	60	Medium sand and fine gravel....	0.224	.....	2.63
4	10.0	15.0	60	Fine gravel and medium sand....	0.220	.....	15.23
				Norfolk Sand			
				TEST-PIT "C," NORTHEAST SAYVILLE			
1	0.0	....	..	Top-soil......................	0.132	.....	2.70
2	....	.75	..	"	0.128	.....	2.75
3	0.75	1.0	3	Subsoil......................	0.138	.....	2.55
4	1.0	1.5	6	"	0.140	.....	2.57
5	1.5	2.0	6	"	0.162	.....	2.43
6	2.0	2.5	6	Sand........................	0.230	.....	2.26
7	2.5	3.5	12	Sand and gravel................	0.238	.....	2.93
8	3.5	4.0	6	" " "	0.242	.....	2.02
9	4.0	4.5	6	Sand........................	0.230	.....	2.65
10	4.5	5.0	6	Sand and gravel................	0.245	.....	2.20
11	5.0	6.5	18	" " "	0.298	.....	2.30
12	6.5	7.0	6	" " "	0.220	.....	1.95
13	7.0	7.5	6	" " "	0.225	.....	2.10
14	7.5	8.0	6	" " "	0.230	.....	2.30
15	8.0	8.5	6	" " "	0.208	.....	2.50
				WELL 660, SOUTHEAST JAMAICA			
1	0.0	1.0	12	Loam and fine sand	0.128	.....	2.91
2	1.0	5.0	48	" " " "	0.200	.....	2.20
3	5.0	10.0	60	Fine gravel and medium sand....	0.220	.....	2.77
4	10.0	15.0	60	Medium sand (little rock flour)...	0.220	.....	2.09

TABLE 43 (*Continued*)

Sample No.	Depth of Sample Below Surface in Feet: From	To	Thickness in Inches	Description of Material	Effective Size	60 Per Cent. Finer Than	Uniformity Coefficient
				Norfolk Sand (*Concluded*)			
				Well 627, South Jamaica			
1	0.0	1.0	12	Loam	.....	0.96	.....
2	1.0	5.0	48	Loam and superfine sand	0.107	.....	5.79
3	5.0	10.0	60	Fine gravel, medium and superfine sand	0.245	.....	8.16
4	10.0	15.0	60	Medium and fine sand	0.229	.....	2.25
				Well 628, South Jamaica			
1	0.0	1.0	12	Loam	.....	0.32	.....
2	1.0	5.0	48	Medium sand and loam	0.117	.....	5.70
3	5.0	10.0	60	Coarse and medium sand (little superfine flour)	0.200	.....	4.00
4	10.0	15.0	60	Fine gravel and coarse sand (little superfine flour)	0.225	.....	4.00
				Well 638, South Jamaica			
1	0.0	0.5	6	Loam	0.160	.....	3.25
2	0.5	1.0	6	Fine sand and subsoil	0.182	.....	3.13
3	1.0	10.0	108	Medium sand	0.213	.....	2.72
4	10.0	11.0	12	" "	0.210	.....	2.33
5	11.0	12.0	12	" "	0.211	.....	1.34
6	12.0	15.0	36	" "	0.190	.....	2.27
				Well 639, Southeast Jamaica			
1	0.0	0.5	6	Loam	0.132	.....	2.71
2	0.5	1.0	6	Medium sand and coarse gravel	0.212	.....	4.13
3	1.0	5.0	48	Medium sand	0.230	.....	2.39
4	5.0	10.0	60	Medium and fine sand	0.245	.....	5.22
5	10.0	15.0	60	Medium sand	0.229	.....	2 16
				Well 659, Southeast Jamaica			
1	0.0	1.0	12	Loam and fine sand	.....	0.380	.....
2	1.0	5.0	48	Fine sand	0.215	.....	1.47
3	5.0	10.0	60	" "	0.192	.....	2.24
4	10.0	15.0	60	Medium sand	0.224	.....	1.83
				Norfolk Coarse Sand			
				Test-pit "B," Northeast Babylon			
1	0.0	0.1	1	Top-soil, humus	0.230	.....	3.00
2	0.1	1.5	17	Subsoil	0.215	.....	3.65
3	1.5	2.3	9	Sand and gravel	0.34	.....	3.00
4	2.3	3.2	10	" " "	0.308	.....	2.64
5	3.2	4.5	17	" " "	0.235	.....	2.03
6	4.5	5.1	7	Sand, gravel and clay	0.0545	.....	7.75
7	5.1	6.0	11	Sand and gravel	0.218	.....	2.40
8	6.0	6.5	6	Sand, gravel and clay	0.0142	.....	13.40
9	6.5	....	..	Sand and gravel	0.200	.....	1.84
				Well 176, Northeast Babylon			
1	0.0	0.25	3	Organic matter and sand	....	.....	.....
2	0.25	1.0	9	Sandy loam	0.17	.....	7.35
3	1.0	3.0	24	Sand, gravel and clay	0.33	.....	7.57
4	3.0	15.0	144	Fine gravel and sand	0.29	.....	3.62
				Stovepipe Well 2, Northeast Babylon			
1	0.0	3.6	43	Gravelly loam	0.43	.....	3.72
2	3.6	4.5	11	Clay and sand	.....	0.51	.....
3	4.5	6.6	25	Fine gravel, coarse and medium sand	0.59	.....	6.61
4	6.6	7.1	6	Fine gravel, coarse and medium sand	0.60	.....	4.66
5A	7.1	10.0	35	Coarse and medium sand	0.45	0.51	2.44
5B	10.0	12.0	24	Coarse gravel	10.5	.....	2.66
6	12.0	13.0	12	Coarse and fine gravel and coarse sand	1.35	.....	12.22
7	13.0	15.0	24	Coarse, medium and fine sand	0.33	.....	1.78

TABLE 43 (*Continued*)

Sample No.	Depth of Sample Below Surface in Feet: From	To	Thickness in Inches	Description of Material	Effective Size	60 Per Cent. Finer Than	Uniformity Coefficient
				Hempstead Gravelly Loam			
				Well 422, Garden City			
1	0.0	2.0	24	Loam and coarse gravel..........	.....	3.30	.....
2	2.0	5.0	36	Coarse and fine gravel and coarse sand........................	0.510	.....	12.16
3	5.0	10.0	60	Fine gravel and medium sand....	0.230	.....	6.52
4	10.0	15.0	60	Fine gravel and coarse sand.....	0.300	.....	4.40
				Well 862, North Hempstead			
1	0.0	1.2	14	Loam........................	0.161	.....	1.32
2	1.2	2.3	13	Fine sand and pebbles..........	0.753	.....	8.13
3	2.3	7.0	56	Medium sand..................	0.318	.....	1.80
4	7.0	12.0	60	Medium sand and pebbles.......	0.230	.....	2.39
5	12.0	15.0	36	Medium sand and coarse gravel..	0.270	.....	4.26
				Well 908, South Central Park			
1	0.0	1.5	18	Coarse gravel and loam.........	0.145	.....	7.93
2	1.5	3.0	18	Coarse gravel and coarse sand....	0.620	.....	6.05
3	3.0	6.0	36	Fine gravel and medium sand....	0.330	.....	6.06
4	6.0	10.0	48	Fine gravel and coarse sand.....	0.370	....	7.03
5	10.0	15.0	60	" " " " "	0.363	.....	7.71
				Hempstead Loam			
				Well 829, West Garden City			
1	0.0	0.5	6	Loam........................	.....	0.23	.....
2	0.5	1.5	12	Loam........................	.....	0.38	.....
3	1.5	8.0	78	Fine gravel and medium sand....	0.230	.....	3.83
4	8.0	15.0	84	Fine gravel and coarse sand......	0.358	.....	4.47
				Well 863, Mineola			
1	0.0	1.2	14	Loam........................	.....	0.24	.....
2	1.2	3.2	24	Coarse gravel and subsoil........	.....	2.08	.....
3	3.2	6.0	34	Fine gravel, medium sand and subsoil......................	0.280	.....	16.07
4	6.0	11.0	60	Fine gravel and medium sand....	0.280	.....	4.43
5	11.0	16.0	60	" " " " "	0.380	.....	6.58
				Well 865, South Bethpage Junction			
1	0.0	1.7	20	Loam and coarse gravel.........	.....	0.22	.....
2	1.7	2.7	12	Superfine sand.................	....	0.21	.....
3	2.7	5.0	28	Fine gravel and superfine sand...	.....	0.23	.....
4	5.0	9.0	48	Fine gravel and medium sand....	0.31	.....	2.97
5	9.0	15.0	72	Coarse gravel and medium sand..	0.30	.....	10.67
				Well 901, Mineola			
1	0.0	2.0	24	Loam.......................	.....	0.44	.....
2	2.0	6.5	54	Coarse and fine gravel and medium sand.......................	0.48	.....	13.33
3	6.5	11.0	54	Coarse and fine gravel and medium sand......................	0.37	.....	6.71
4	11.0	16.0	60	Fine gravel and medium sand....	0.35	.....	11.14
				Well 1142, North Hicksville			
1	0.0	1.5	18	Loam	.....	0.23	.....
2	1.5	4.0	30	Fine sand and coarse gravel......	0.28	.....	7.27
3	4.0	6.0	24	Coarse and medium sand and coarse gravel	0.23	.....	4.56
4	6.0	11.0	60	Coarse and fine sand, coarse gravel	0.51	.....	7.25
5	11.0	16.0	60	Fine gravel and medium sand ...	0.29	.....	3.72

TABLE 43 (*Concluded*)

Sample No.	Depth of Sample Below Surface in Feet — From	To	Thickness in Inches	Description of Material	Effective Size	60 Per Cent. Finer Than	Uniformity Coefficient
				HEMPSTEAD LOAM (*Concluded*)			
				WELL 906, NORTHEAST WILLISTON			
1	0.0	2.7	32	Loam	.....	0.34	.....
2	2.7	7.5	58	Fine sand and fine gravel	0.21	.....	5.34
3	7.5	12.2	56	Coarse and fine gravel, coarse, medium and fine sand	0.27	.....	14.50
4	12.2	17.5	64	Fine gravel and medium sand	0.22	.....	6.27
				WELL 907, NORTH FLORAL PARK			
1	0.0	0.8	10	Loam	.....	0.28	.....
2	0.8	2.5	20	Subsoil	.....	0.28	.....
3	2.5	6.0	42	Fine gravel and medium sand	0.28	.....	8.73
4	6.0	10.0	48	Coarse and medium sand	0.23	.....	2.56
5	10.0	15.0	60	Fine gravel and coarse sand	0.35	.....	5.48
				WELL 909, SOUTH HICKSVILLE			
1	0.0	2.5	30	Loam	.....	0.55	.....
2	2.5	5.0	30	Fine gravel and fine sand	0.24	.....	3.00
3	5.0	10.0	60	Fine gravel and medium sand	0.24	.....	4.04
4	10.0	15.0	60	Fine gravel and medium sand (little superfine sand)	0.21	.....	2.88
				WELL 955, SOUTH HICKSVILLE			
1	0.0	1.0	12	Loam	.....	0.25	.....
2	1.0	2.5	18	Subsoil	.....	0.73	.....
3	2.5	4.5	24	Coarse gravel, coarse sand and subsoil	0.24	.....	13.62
4	4.5	6.0	18	Coarse gravel and coarse sand (little rock flour)	0.64	.....	6.64
5	6.0	10.0	48	Coarse gravel and medium sand	0.45	.....	11.56
6	10.0	15.0	60	Coarse sand, fine gravel and medium sand	0.22	.....	10.00
				WELL 959, NORTH MINEOLA			
1	0.0	3.0	36	Loam	.....	0.14	.....
2	3.0	8.0	60	Subsoil	.....	*0.10	.....
3	8.0	10.5	30	Coarse sand and superfine flour	0.18	.....	7.50
4	10.5	15.0	54	Fine gravel and coarse sand	0.20	.....	4.25

*Than which 61 per cent. is finer

The effective size of these loams and subsoils probably lies between 0.03 and 0.15 millimeter. The coarse sands and gravels beneath the loam and subsoil range in effective size from 0.20 to 0.60 millimeter or more. Even the finer soils frequently contain much gravel and consequently have large uniformity coefficients. The porosity of the top-soils and substrata varies from 30 to 45 per cent. of their total volume, being somewhat larger for the finer and more uniform soils.

Movements of Soil Moisture

It has been pointed out that only a small portion of the rain that falls on the surface of southern Long Island runs off over the surface; the remainder, if not immediately evaporated, sinks quickly into the coarse soils and substrata. The subsequent movements of this water in the pore spaces of the soil may be outlined as follows:

(1) A portion under the influence of gravity, possibly aided by capillarity, sinks through the soils and substrata to replenish the ground-water reservoirs in the pore spaces of the deep water bearing gravels.

(2) Some is retained in the pore spaces of the soil by capillarity or surface tension due to molecular forces on the surface of the films of water that surround the sand grains. A portion of this moisture is absorbed slowly by the fine roots of vegetation and dissipated by the foliage above the surface, or is used up by the minute plant life and the small animals in the top-soils.

(3) Another portion likewise retained in the soils is drawn by capillarity to the surface of the ground and evaporated.

(4) Still another small portion of the moisture may be lost to the air within partially saturated soil by interior evaporation.

The relative proportion of the rainfall that disappears in these ways varies greatly during the year. The percolation to the deep strata is larger during the colder months when the surface evaporation is small and plant life is inactive, and is little or nothing in summer, when the moisture is rapidly dissipated by evaporation or taken up by vegetation.

Percolation Under Influence of Gravity

Experiments have shown that the rate of downward percolation of soil moisture depends upon the coarseness of the

soil, the temperature and the amount of moisture contained. The pore spaces of a coarse soil are larger and the force of capillarity opposes less resistance to the downward movement of the water under the influence of gravity than in a fine soil. Whatever the texture of the soil, this resistance of capillarity decreases with the amount of moisture contained and with the increase in temperature or decrease in viscosity.

The velocity of the gravitational movement of the water in the soil is small. The observations of the Burr-Hering-Freeman Commission, shown graphically in Plate VI of Appendix VII of their report, following page 792, and discussed on pages 798 to 805, indicate that the velocity of percolation in the coarse outwash plains averaged about one foot per day during the spring and summer of 1903, ranging from 0.5 foot to 5.0 feet per day. The rate of movement evidently increased in late summer after the early rains had filled the ground with moisture and was greater during the entire season through the first ten feet than for greater depths.

In Bulletin No. 10, U. S. Department of Agriculture, Division of Soils, Lyman J. Briggs states on page 20:

"If the soil is nearly saturated, so that the films connecting the capillary spaces are short and thick, and the capillary spaces themselves are not active, but little resistance is offered to the movement of water and the addition of water at the surface is quickly felt farther down. If, on the other hand, the soil contains but little water, the same amount of water added to the surface, while producing marked changes in the upper layers, will not be felt so quickly at the lower depths on account of the activity of the upper capillary spaces and the length and small cross-section of the connecting films."

Light rains in summer on dry soil are, therefore, less effective than in spring and fall when the soil is moist.

Movement of Soil Moisture by Capillarity

The downward percolation of water in soil may be assisted by capillarity when the surface tension of the water in the deeper soils is greater than at the surface. The condition arises as a result of a lower temperature at the bottom and greater viscosity there, or it may result where the deeper layers are made up of finer grains or contain less moisture than the surface soil. Capillarity, or surface tension, is of greatest importance, however, in arresting the downward movement of

the rains in the soils and retaining the moisture there during the growing period for the uses of vegetation.

If the soil is already moist before a rainfall, some of the rain-water may be drawn down by gravity because the surface tension cannot retain all of it. As the soil fills with water the films connecting the capillary spaces become short and thick, the curvature of the films becomes small, and surface tension, which is resisting the gravitational movement, is decreased. Under these circumstances, a portion of the water flows downward until an amount remains in the soil that the surface tension can support. Should, however, there be but little moisture in the soil previous to a shower only a small portion of the rain may get far below the surface, and this portion will move very slowly in the dry soil. Most of the rain-water will be distributed in the top-soil, according to the moisture content and the texture of the several layers until a condition of equilibrium is reached. A new distribution of this moisture constantly takes place, however, as the small roots of vegetation distributed through the soil mass absorb the water from the enclosing sand grains, and moisture from other portions of the soil moves in, through capillarity, to take its place. Furthermore, the moisture in the layer of soil at the surface is constantly evaporated, and the moisture in the soil beneath the surface moves upward to be in turn evaporated. The rate of capillary movement increases directly with the fineness of the soil and up to a certain degree of saturation with the moisture content, and increases inversely with the temperature.

Interior Evaporation

Moisture in the soil is also dissipated at times by interior evaporation, currents of air, moving in and out, as the "soil breathes" take up a small amount of water from the films that surround the sand grains and remove it as aqueous vapor. This loss is probably not inconsiderable in an open, porous soil of small moisture content through which the air freely moves under changes of temperature and barometric pressure. When the amount of moisture in the soil becomes too small for capillary movement, it exists as hygroscopic water on the soil grains and is doubtless removed by the air moving through the soil. The amount of this loss has not been studied to any extent, and it is not known whether plants secure any moisture from the air within the soil.

MAXIMUM CAPILLARY RISE OF WATER IN LONG ISLAND SOILS

Among other investigations on the physics of Long Island that were made in 1903 by the Burr-Hering-Freeman Commission, a series of experiments was carried on to determine the limit of upward capillary movement of moisture in partially saturated soils, which are fully described in the report of the commission, pages 603 to 613. Long Island sands, sifted but not washed, were selected for this work. The final results of these experiments are exhibited on Sheet 138, Acc. L 660, taken from page 612 of the report. This diagram shows the limit of "partial capillarity" as it is called, or the greatest hight to which moisture rises through surface tension in partially saturated sands of a given effective size. From the upper curve of this diagram, which represents the maximum hight through which an appreciable amount of water was observed to move in wet soils, the maximum rise corresponding to effective size is as follows:

Effective Size of Soil in Millimeters	Limit of Partial Capillarity in Feet
0.03	7.00
0.05	6.00
0.10	4.25
0.20	2.75
0.30	2.00
0.40	1.65
0.50	1.40
0.60	1.25
0.70	1.15
0.80	1.05
0.90	0.95
1.00	0.90

For material of the fineness of the Long Island loams and subsoils, which have an effective size of from 0.03 to 0.15 millimeter, it appears that the limit of capillary rise, when wet, is from four to seven feet. From the lower curves of the diagram it is evident, however, if the material is dry, that moisture does not rise in even the finest soils over two feet.

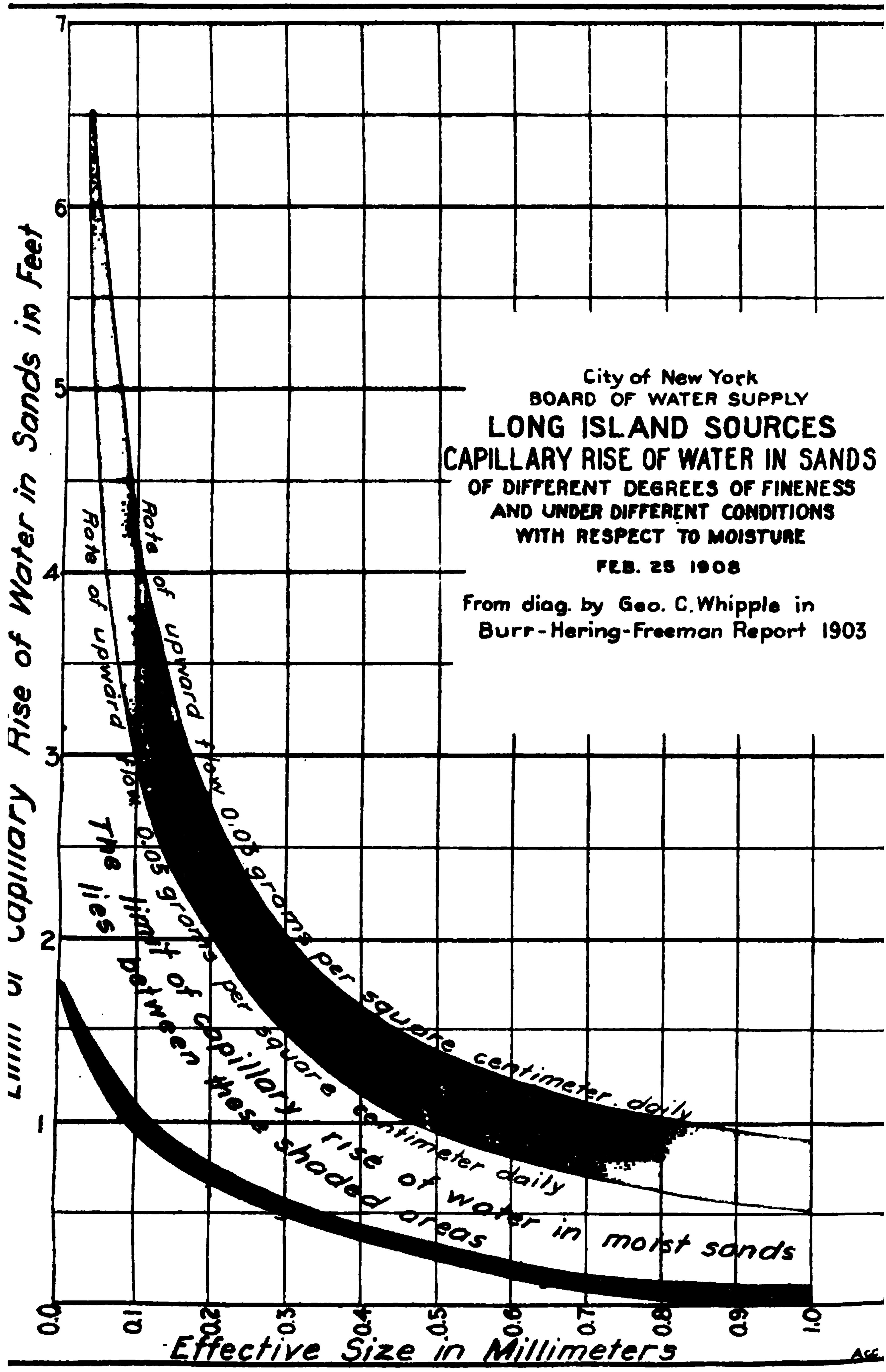
It should be noted, however, that the thickness of these fine soils in the plains of southern Suffolk county is in no

case much over 36 inches, and, if the surface of the ground-water is below the subsoil, vegetation is dependent upon the amount of moisture that the force of capillarity draws up through the coarse sands and gravels underlying the subsoils into which the roots do not penetrate. It has been noted that the effective sizes of the coarse sands and gravels range from 0.20 to 0.60 millimeter; from the above table it appears that water does not rise in such material, even when wet, to a greater hight than one to three feet, and moisture determinations taken in test-pits, excavated in 1903, to the water-table confirm these figures. In dry material of these effective sizes, moisture does not even rise as much as 12 inches.

Under the most favorable conditions, moisture cannot, therefore, reach the roots of plants through these substrata of coarse sand if the moisture has to pass from a ground-water surface through a hight of more than three feet. If the depth of soil and subsoil is, on the average, 30 inches, and the sands and gravels below are of such texture that the average capillary rise below the subsoil is say 24 inches, it is evident that vegetation can obtain no moisture from the water-table or the surface of saturation when this is over 54 inches below the ground surface, or let us say five feet, to be on the safe side.

In order to confirm these conclusions by full size experiments on the natural soils and substrata of Long Island that would be more convincing to the average man than the deductions from the above investigations of 1903, a series of experiments was planned in the fall of 1907 and carried out at the Varick Street laboratory during the ensuing five months. Galvanized-iron tanks six inches in diameter and six feet long, open at both ends, with a screen at the bottom, were filled with soil at three representative localities along the line of the proposed collecting works in southern Suffolk county as follows:

Test-pit	Type of Soil from U. S. Bureau of Soils	Location	Depth of Top-soil in Inches	Depth of Subsoil in Inches
A	Norfolk coarse sandy loam.	Cultivated field 1½ miles northwest of Babylon on North street, 200 yards east of Belmont avenue.	10	24
B	Norfolk coarse sand	"Babylon experiment station," West Islip, in scrub oak barrens	1	17
C	Norfolk sand	Corn field on property of H. E. Bergen, near Sans Souci lakes, 2 miles northeast of Sayville.	9	15


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
CAPILLARY RISE OF WATER IN SANDS
OF DIFFERENT DEGREES OF FINENESS
AND UNDER DIFFERENT CONDITIONS
WITH RESPECT TO MOISTURE
FEB. 25 1908
From diag. by Geo. C. Whipple in
Burr-Hering-Freeman Report 1903
Rate of upward flow 0.08 grams per square centimeter daily
Rate of upward flow 0.05 grams per square centimeter daily
The limit of capillary rise of water in moist sands
lies between these shaded areas
Effective Size in Millimeters
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Rise of Water in Sands in Feet
1
2
3
4
5
6
7
Acc.

Two tanks were taken from each pit; one at each point called A-1, B-1 and C-1, respectively, represented a complete section from the surface; the second, designated A-2, B-2 and C-2, respectively, was not intended to include the top-soil.

The tanks were carefully filled in an inverted position on the ground, samples of each stratum taken in jars for mechanical analysis, and all shipped to Varick Street laboratory. The tanks were there placed within others about eight inches in diameter, as shown in the sketch on Sheet 139, Acc. L 500. A tube two inches in diameter on the outside of the larger tanks and connecting at the bottom served to show the hight of water in both the outer and the inner tank. It was planned to maintain the "ground-water" level in these soils at different levels and determine the amounts of water that were carried to the surface by capillarity and evaporated, by observing the loss of weight of the cans at proper intervals. Temperatures of the surface soils were taken daily, and the humidity and temperature of the air in the room observed. The soil surface was maintained so far as possible flush with the top edge of the tanks, and the evaporation at the surface was increased by an electric fan, which ran during the daylight hours.

Frequent rains in November had saturated the ground with water and the soils in the tanks were wet when taken to the laboratory. Some time was necessary to evaporate the surplus water and the early measurements were consequently unsatisfactory and were discarded. When the weighing experiments were completed with the "ground-water" surface at the bottom of the tubes, the amount of moisture remaining in the soils was determined. These experiments have been in charge of Assistant Engineer James L. Davis, who has been advised throughout the work by Mr. George C. Whipple, Consulting Engineer, who has worked up the final diagrams of results shown on Sheets 140 to 145, inclusive, Accs. L 1018 to L 1023, inclusive.

These diagrams show the texture of the soils in the tanks, the loss of water, with the water surface at various depths below the surface of the soil and the moisture content at the close of the experiment. The amount of loss from the tanks, taken from the curves of these diagrams, is shown in the table on page 539, which presents the following facts:

When the water stood one foot below the soil surface, the

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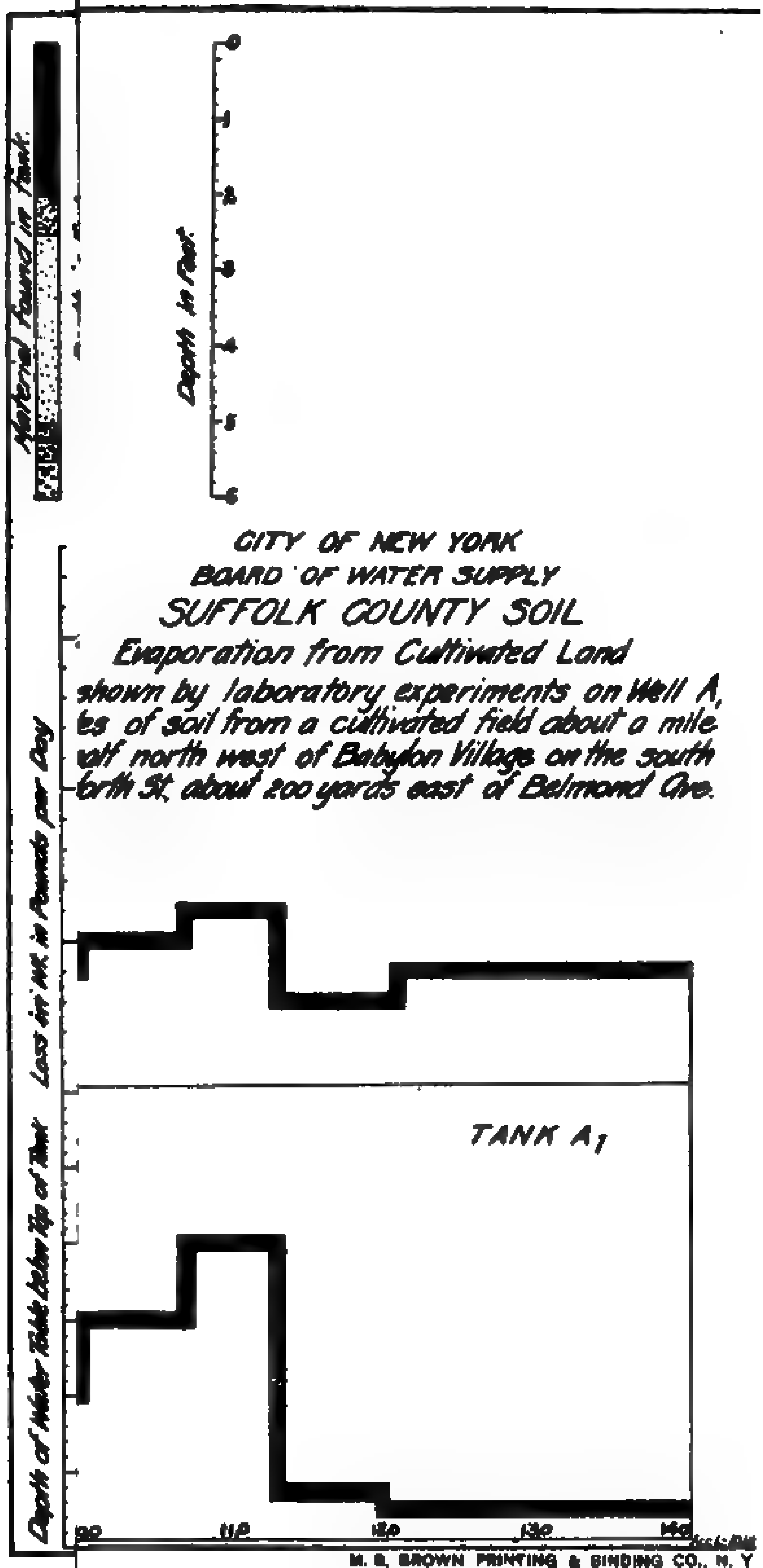
(Not to Scale)

City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
APPARATUS FOR TESTS
ON CAPILLARY ACTION
SKETCH
OCT. 23-1907.

B.W.S. 163 Acc. L500



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losses from the tanks which had a soil cover amounted to 0.09 to 0.20 pound per day, and were apparently proportional to the fineness as well as the entire depth of the soil and subsoil. These figures agree very well with the results of similar experiments made by the Burr-Hering-Freeman Commission at Floral Park in 1903. (See Report, pages 766 to 768 and Plate III following page 770.)

When the water was two feet below the surface of the soils in Tanks A-1, A-2 and C-1, which had soil layers at this depth, the losses were from 0.065 to 0.10 pound per day. Where this depth of water surface was below the subsoil in the two tanks, B-1 and C-2, the losses were only 0.02 to 0.05 pound. As before, the losses were, in general, proportional to the fineness and depth of the soil and subsoil. This was also true when the water surface was three feet below the soil surface.

The losses of moisture when the water surface in each tank was at the same distance below the fine subsoil, gives a better comparison of the several substrata.

EVAPORATION FROM LONG ISLAND SOIL IN TANKS
AT VARICK STREET LABORATORY

	Tank Number					
	A-1	A-2	B-1	B-2	C-1	C-2
Thickness of soil and subsoil in feet	2.8	2.1	1.5	0.0	2.0	1.3
Effective size of surface soil	0.063	0.06	0.280	0.32 sand	0.155	0.14 gravelly
Effective size of sand below subsoil	0.245	0.25	0.440	0.30	0.210	0.25
Evaporation in pounds* per day when water was 1 foot below surface and in subsoil layers	0.200	0.120	0.090	0.025	0.140	0.030
Evaporation in pounds per day when water was 2 feet below surface; in subsoil layers of Tanks A-1, A-2 and C-2, and below these layers in others	0.090	0.065	0.053	0.017	0.090	0.020
Evaporation in pounds per day when water was 3 feet below surface and below all subsoil layers	0.048	0.045	0.035	0.012	0.048	0.012
Evaporation in pounds per day when water was 1 foot below the bottom of subsoil	0.040	0.045	0.042	†0.023	0.048	0.016
Evaporation in pounds per day when water was 2 feet below the bottom of subsoil	0.035	0.038	0.025	†0.017	0.020	0.010

*For these tanks, six inches in diameter, a loss of one pound of water per day is approximately equivalent to one inch in depth of water daily upon the surface of the tanks

†Losses at one and two feet, respectively, below the surface of the sand in the tank

Only 0.016 to 0.045 pound per day was lost when the water surfaces were one foot below the subsoils and only 0.010 to

0.038 pound per day when the water surface was two feet below.

The greater losses in the tanks which had the thicker layers of soil and subsoil, even when the water surface was in the coarse sand two feet below the finer material, suggests that some of this loss represented the evaporation of capillary and hygroscopic moisture from the fine surface soils. The amount of moisture in these top-soils at the close of the experiments was considerable after they had been cut off from any source of supply for a month. It is reasonable, therefore, to suppose that the amount of moisture that was carried upward one foot by surface tension in the coarse substrata was about 0.02 pound rather than the larger values that appear in the Tanks A-1, A-2, B-1 and C-1 which had a soil cover, and it is probable that the amount of moisture that was raised through two feet of these coarse sands was still less. Further experiments of longer duration on tanks of greater hight seem desirable.

The amount of moisture required by growing crops is given by Risler as follows:

Crop	Consumption of Water in Inches per Day
Meadow grass	0.134 to 0.267
Oats	0.140 to 0.193
Indian corn	0.110 to 0.157
Clover	0.140 to .....
Vineyard	0.035 to 0.031
Wheat	0.106 to 0.110
Rye	0.091 to .....
Potatoes	0.038 to 0.055
Oak trees	0.038 to 0.035
Fir trees	0.020 to 0.043

Evidently an amount of moisture equivalent to the probable rise of water in pounds per day in these coarse Long Island sands, through even one foot in hight, which may be placed at 0.02 inch in depth, is insufficient for any of the crops grown on Long Island and hardly enough for oak and fir trees.

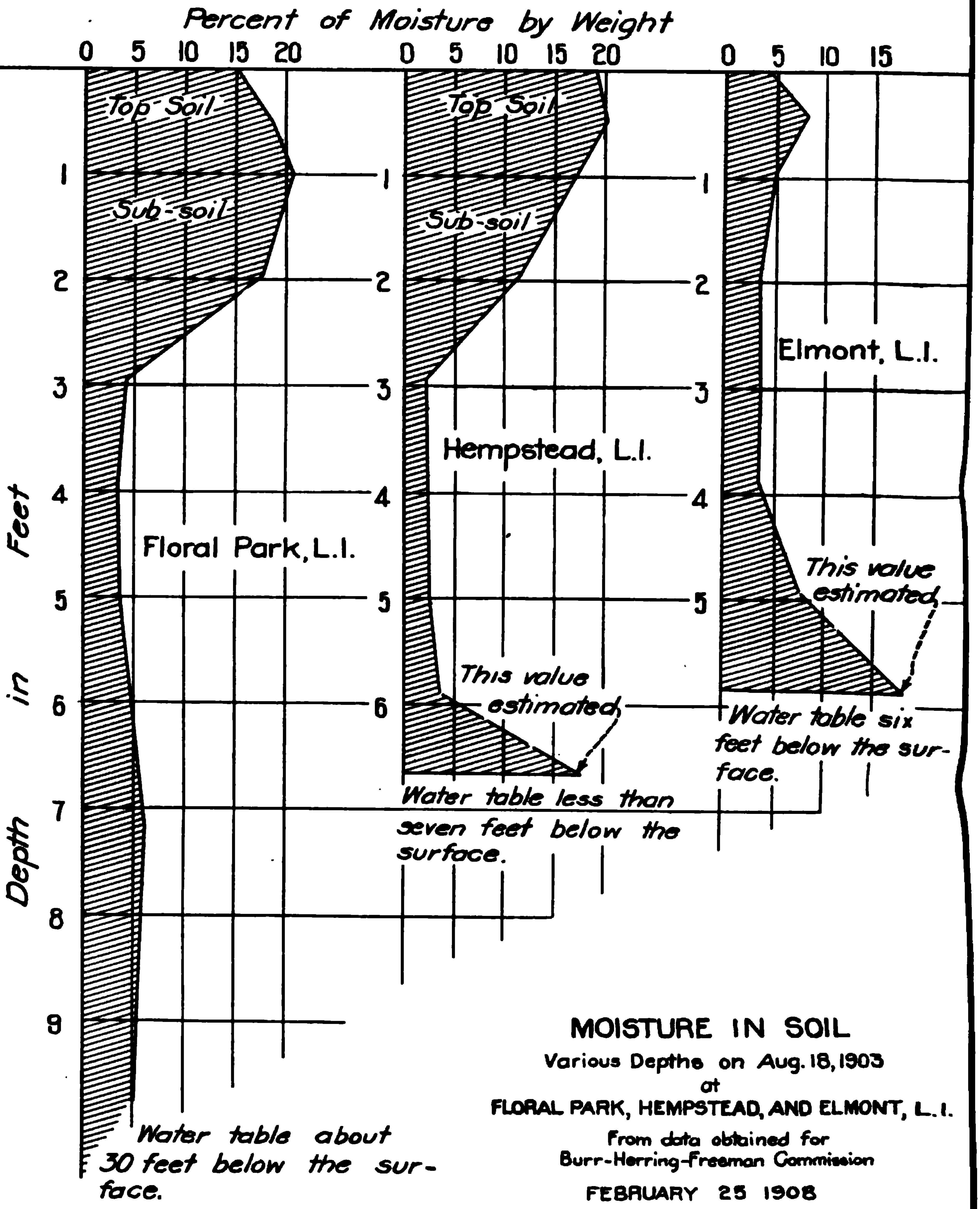
The fact that the loss of moisture was but little less when the surface of saturation was two feet below the subsoil, and the uniformity of the small loss in Tank B-2, which had no soil cover, suggest that some of these losses may have been due to interior evaporation rather than to capillary rise in the coarse sands.

It is not likely that the roots of vegetation can obtain any moisture that has been evaporated from a water surface within the sands several feet below the subsoils, because the temperature at this depth would be lower than that of the soils in which the roots lie, and the moisture-laden air rising to the surface would increase in temperature, and no moisture would be condensed where the roots could reach it. Of course, some might be condensed in the surface layers at night, but the cooling during the night hours does not extend far below the surface. More water would probably come in this way as dew from the atmosphere than from the interior sources.

From all these considerations of the losses of moisture from the tanks and the diagrams showing the moisture content of the soils at the end of the experiments, it appears that no appreciable amount of moisture is drawn upward by capillarity in the coarse sands that underlie the Suffolk County plains soils through a greater distance than two feet. Even if a small amount of moisture is raised through a greater distance as aqueous vapor by air within the soil mass, it is unlikely that such moisture would be available to the roots of vegetation in the soil.

Conservation of Soil Moisture

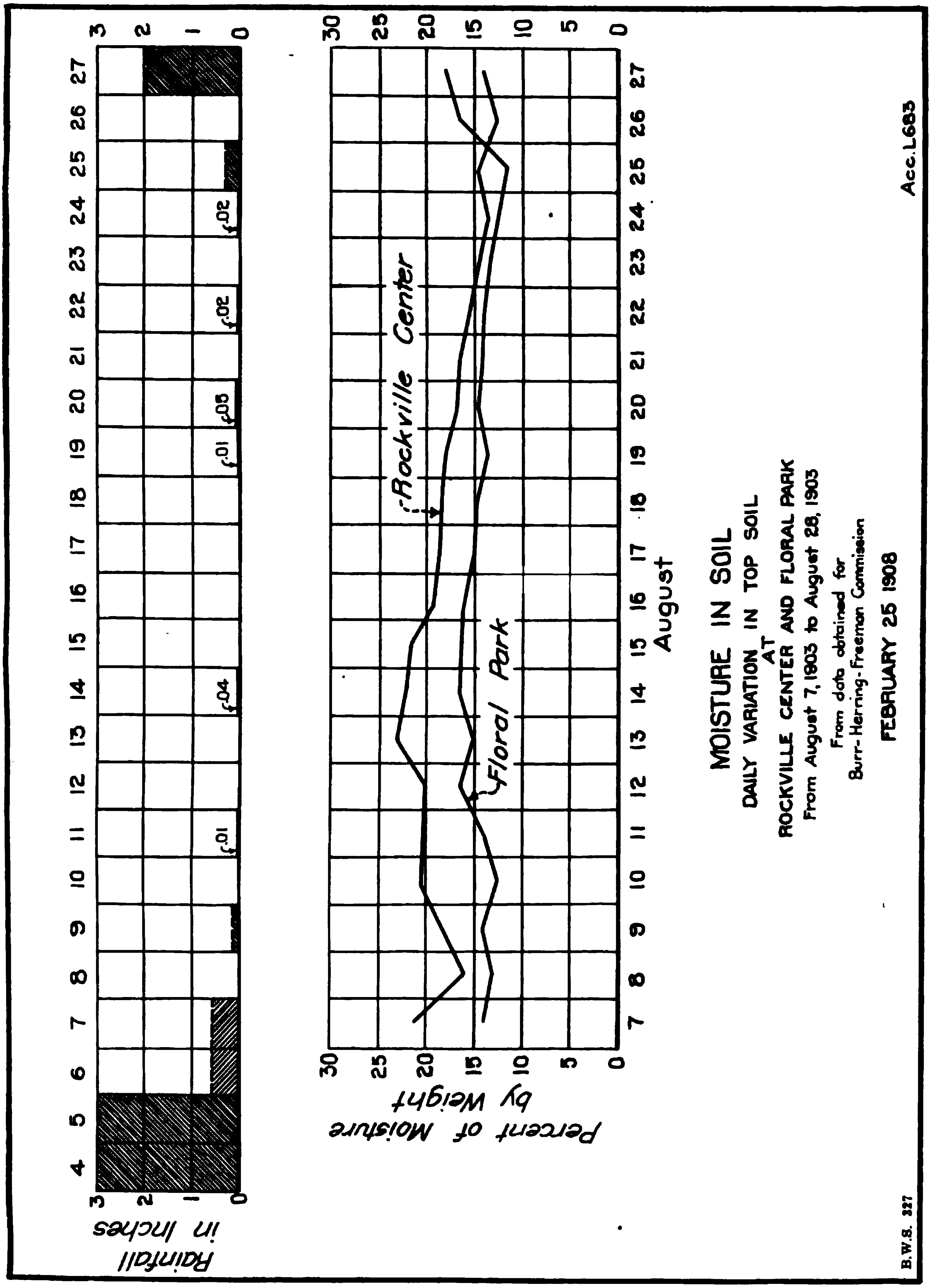
It has been mentioned in the preceding pages that the results of the tank experiments on the Suffolk County soils indicated that the finer top-soils retained their moisture for many weeks after they were cut off from the source of supply by the lowering of the water-table. The amount of moisture that may be retained in fine top-soils is also exhibited in Diagram 54 in the report of the Burr-Hering-Freeman Commission, page 603. Two diagrams recently compiled by Mr. George C. Whipple, from unpublished data obtained by this commission in 1903, are exhibited on Sheets 146 and 147, Accs. L 682 and L 683. The first shows that the loams and subsoils at Floral Park and Hempstead, which are typical of the better Long Island soils, contained five to seven times the amount



MOISTURE IN SOIL
Various Depths on Aug. 18, 1903
at
FLORAL PARK, HEMPSTEAD, AND ELMONT, L. I.
From data obtained for
Burr-Herring-Freeman Commission
FEBRUARY 25 1908

B.W.S. 338.

Acc. L682.


MOISTURE IN SOIL
DAILY VARIATION IN TOP SOIL
AT
ROCKVILLE CENTER AND FLORAL PARK
From August 7, 1903 to August 28, 1903
From data obtained for
Burr-Hering-Freeman Commission
FEBRUARY 25 1908
Rainfall in Inches
Percent of Moisture by Weight
August
Rockville Center
Floral Park
.01
.04
.01
.05
.02
.02
Acc. L683
B.W.S. 327

of moisture that existed in the coarse sands and gravel beneath. The second diagram shows the retentiveness of these soils during a portion of the month of August, 1903. No rainfall of any consequence occurred between the 7th and the 25th, yet there was nearly as much moisture in the soil at Floral Park at the end of this 18th day period as in the beginning. The soil at Rockville Center lost, in the same time, about one-third of its moisture content. No attempt was made in either case to prevent the loss of moisture by the ordinary methods of cultivation.

These are but typical of the moisture conditions in the surface strata throughout Long Island, where there is a soil covering suitable for agricultural purposes. Without the reservoir of moisture that exists as capillary water in the finer top-soils, crops could not be grown on these sandy plains where the soil is over two or three feet above the water-table, unless it rained almost constantly. The porous leachy soils in Suffolk county only support crops when they are made finer and more retentive of moisture by turning in manure or other organic matter.

Various methods of conserving moisture in the soil are familiar to the farmer. A mulch of soil is created by loosening up the earth for three inches or more in depth, and sometimes a mulch of straw or manure is spread on the surface of the ground to prevent the escape of the moisture. The mulch rapidly dries out, and interposes, between the soil filled with moisture and the dry air, a layer that, because of its loose character and its dryness, prevents the rapid movement of the moisture through it to the surface.

The surface of the soil is usually cultivated after a heavy rain and most frequently in the spring, to save the water that has entered the ground during the winter. Subsoiling and deep fall ploughing serve the same purpose, and these may not only conserve but increase the soil moisture by making the conditions favorable for the movement of moisture from other strata toward the soil in which the roots of the crops are feeding. Many interesting experiments on the conservation of soil moisture have been made by Prof. F. H. King at the University of Wisconsin, which are described in his " Physics of Agriculture."

The surface soils of the outwash plains in Suffolk county, as well as those in western Long Island, with little exception,

are entirely dependent upon the moisture that they retain for the growth of crops. It will be shown that on only a very small percentage of the outwash plains is the surface of saturation in the substrata sufficiently near the surface soils to supply the growing crops with moisture. The possibilities of even the coarse open soils of the Suffolk County scrub oak barrens to retain the moisture needed for all varieties of crops, were demonstrated last year by Mr. H. B. Fullerton of the Long Island railroad, at Medford, on the Main line of the Long Island railroad.

Several acres of land were purchased within the area designated by the Bureau of Soils as Sassafras gravelly loam. This was cleared of the scrub oak forest; wood ashes were added to make the soil alkaline and the natural humus and some stable manure were turned in. The water-table is 40 feet below the ground surface of this experimental farm, and moisture could not possibly have reached the surface from such a depth; yet, with this preliminary treatment, and by means of approved methods of cultivation or "dry farming" during the growing season, splendid crops of vegetables of all varieties were grown without other moisture than fell on the surface. The rainfall in Suffolk county, during the summer of 1907, was not large and that for the whole year was slightly below the normal. Vegetable crops failed on farms near this experiment station where the soils were not properly cultivated, to retain the summer rains. The success of the Medford station can be repeated elsewhere in Suffolk county, where the soils are equally good, regardless of the hight of the surface above the ground-water.

EXTENT OF SUFFOLK COUNTY AGRICULTURAL INTERESTS

The areas under cultivation within the catchment area of the proposed Suffolk County supply are shown on Sheet 149, Acc. 5334, which exhibits the character of the surface vegetation on this area, the location of the larger villages and the relation of these and the cultivated areas to the line of the proposed collecting works.

The relative areas under cultivation, in pasture, sproutland, woodland, meadow of fresh marsh and salt marsh, are given in the table following. Only 30,000 acres, or 15 per cent. of

the entire catchment area of 332 square miles, is cultivated, and some of this is unprofitable grass land. The character of the crops on these cultivated lands in 1907 is shown by the small letters on this map. Where no letters are shown, hay crops were grown. As already stated, a larger percentage of the moraines is under cultivation than the outwash plains. One-quarter of the moraine surface within the southerly Suffolk County catchment is under cultivation, whereas only 15,000 acres, or 11 per cent. of the outwash plains, are devoted to agricultural uses.

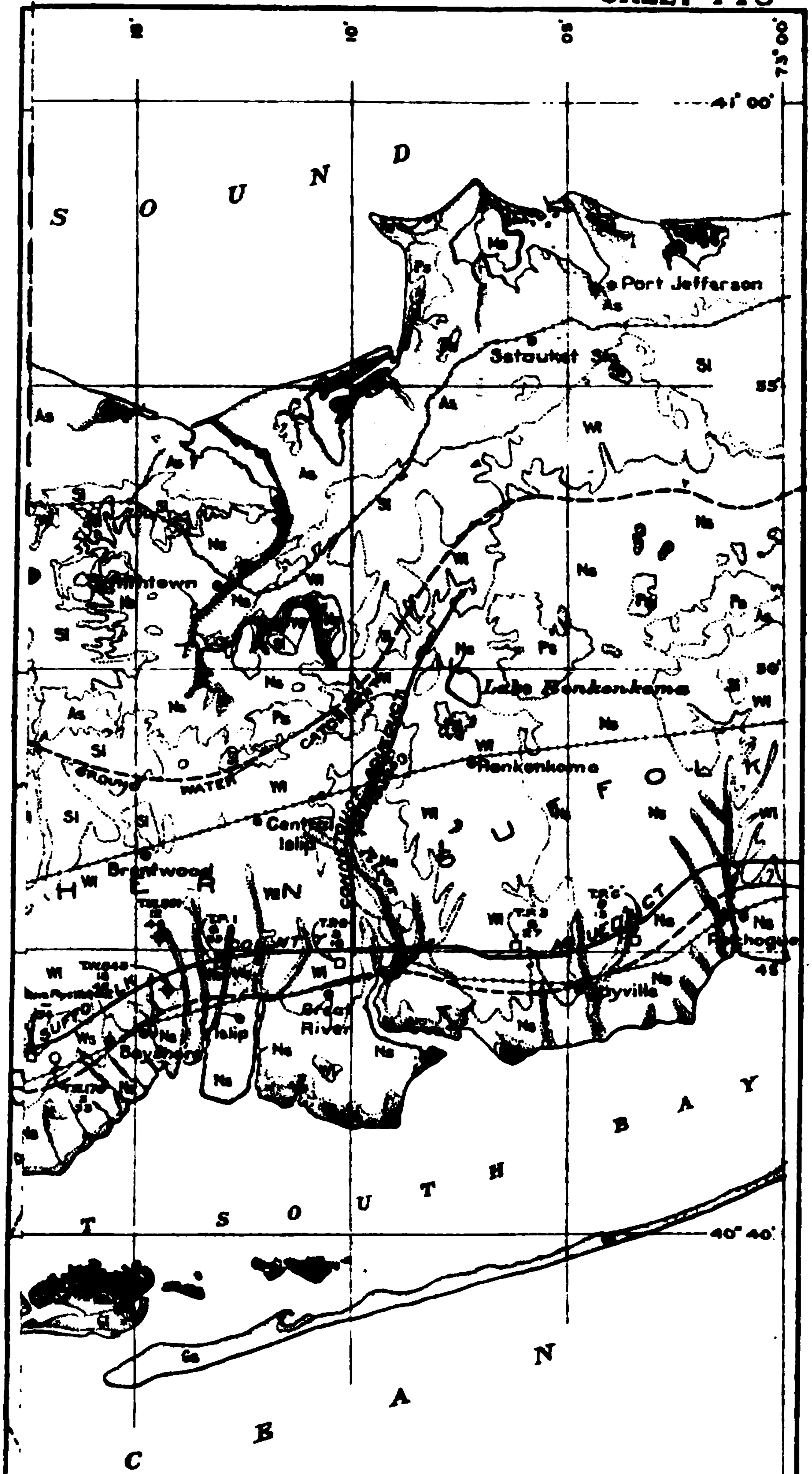
SURFACE CHARACTER OF SUFFOLK COUNTY WATERSHEDS

Character of Surface	Ground-water Catchment of the Southern Suffolk County Sources			Ground-water Catchment of the Peconic Valley Sources Total	Total Ground-water Catchment of the Proposed Suffolk County Sources
	Outwash Plains	Moraines	Total		
Cultivated					
Area in square miles....	23.93	20.55	44.48	4.63	49.11
Percentage of total.....	11.3	25.1	15.14	12.18	14.81
Pasture					
Area in square miles....	1.50	3.16	4.66	0.07	4.73
Percentage of total.....	0.7	3.8	1.59	0.19	1.42
Sproutland					
Area in square miles....	123.20	29.50	1 2.70	11.02	163.72
Percentage of total.....	58.4	36.1	2.00	29.02	49.38
Woodland					
Area in square miles....	57.17	28.16	85.33	19.13	104.46
Percentage of total.....	26.8	34.4	29.06	50.37	31.48
Fresh Marsh					
Area in square miles....	5.86	0.49	6.35	3.13	9.48
Percentage of total.....	2.73	0.6	2.16	8.24	2.86
Salt Marsh					
Area in square miles....	0.16	0.00	0.16	0.00	0.16
Percentage of total.....	0.07	0.00	0.05	0.00	0.05
Total square miles........	**211.82**	**81.86**	**293.68**	**37.98**	**331.66**
Per cent. of total.........	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Much of this cultivated land in southern Suffolk county is, furthermore, far from the line of the proposed south shore collecting works. Only about 9,000 acres, or 30 per cent. of this cultivated land, is within a distance of one mile of the proposed works.

Effect of Operation of Works on Well Supply

There can be no doubt that the water surface in wells within a few hundred feet of the proposed collecting works would, by their operation, be lowered several feet; but most of this depression of the ground-water table would take place



City of New York

BOARD OF WATER SUPPLY

LONG ISLAND SOURCES

CHARACTER OF SURFACE SOILS

From map prepared by Bureau of Soils
U.S. Dept. of Agriculture for Report of 1903

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FEBRUARY 25, 1908

Acc L 646

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within the 1000-foot right-of-way that it is proposed to purchase. The lowering of the water in any wells outside of this right-of-way would not be much greater than the normal fluctuation in the water-table that takes place in the course of years through the variation in the amount of rainfall. The additional lift in such wells that might at times be necessary because of the pumping of the proposed works would not be sufficient to cause much annoyance. Water for all purposes could be drawn as readily after the works were in operation as before. The proposed location is, in general, so far back from the villages and farms along the south shore and in the Peconic valley that but few domestic wells would be seriously affected.

Effect of Proposed Works on Soil Moisture

The dotted lines on the map, Sheet 149, Acc. 5334, are lines of equal depth of the water-table, or the surface of saturation below the ground surface. It is evident that on the whole length of the line in southern Suffolk county the ground surface is generally over 5 feet, and seldom less than 10 feet above the ground-water surface, except within the valleys of the larger streams. The experiments on soil moisture have shown that only within the areas enclosed by the lines of five feet depth of ground-water where the water-table is less than five feet from the surface, would the lowering of the ground-water through the pumping on the proposed line possibly decrease the amount of moisture in the soil. Outside of the 5-foot lines on the map where the ground surface is more than this hight above the water-table, the amount of moisture in the surface soils is independent of the movement of the ground-water. All vegetation in the soils where the surface is more than five feet above the ground-water, secure only the water from the rains that the soils are able to retain as it passes down to the deep water bearing strata.

The total area of surface of the whole Suffolk County catchment area, within which the ground-water is less than five feet below the ground surface, is only 15,000 acres, or seven per cent. of the whole area of 212,000 acres, or 332 square miles; and in the catchment of the southern Suffolk County sources, but little more than five per cent. of the surface is within this hight above the ground-water as follows:

WATERSHED	TOTAL AREA	CATCHMENT AREA, LESS THAN 5 FEET ABOVE GROUND-WATER SURFACE
Southern Suffolk County sources		
Area in square miles	293.7	15.32
Per cent. of whole	....	5.20
Peconic Valley sources		
Area in square miles	38.0	7.92
Per cent. of whole	....	20.90
Total catchment area in square miles	**331.7**	**23.24**
Per cent. of whole	....	**7.00**

The vegetation supported by the soils on 93 per cent. of the entire catchment area obtains no moisture from the water-table below them. Not all of the small area in which the water-table is less than five feet below the surface would be affected by the proposed ground-water collecting works, because the ground-water surface would not, at any time, be greatly depressed beyond a distance of one mile from the collecting works.

Within a belt one mile either side of the collecting works in southern Suffolk county, only 8000 acres, or 4.3 per cent. of the surface of the entire catchment area, would be within five feet of the ground-water, and the moisture of the soils in only this small portion of the watershed would be effected. This area, however, includes about 3000 acres of meadow and marsh land in the bottom of the valleys, now worthless for agriculture, that could be cultivated if the water were depressed below the top-soils, so that only 5000 acres, or 2.7 per cent. of the entire catchment area in southern Suffolk county could be effected injuriously by the proposed collecting works, and 3000 acres of marsh land, or 1.6 per cent., would, at the same time, be improved. The land on which the soil moisture would be decreased by the operation of the proposed works is not by any means occupied by farms at this time. Only 750 acres, or 0.4 per cent. of the watershed, could possibly be injured now.

About 2100 acres, or 8.7 per cent. of the surface within a mile of the Peconic Valley collecting works is within five feet of the ground-water, and of this area about 1000 acres is in swamp and water surface, and only 100 acres, or 0.4 per cent. of the catchment area of 38 square miles, is under cultivation.

The branch lines in the interior valleys would be operated

only at intervals of several years, when the rainfall was deficient, and the small areas of low ground in the narrow valleys, in which the soil moisture, on rare occasions, might be diminished, have not been considered.

The total area within the entire Suffolk County catchment area of 332 square miles, or 212,000 acres, in which the surface soil is less than five feet from the ground-water and within a mile of the main collecting works, is only 10,100 acres, or 4.8 per cent. of the whole, and this includes about 4000 acres of water surface and swamps that would be benefited by any lowering of the ground-water surface. Of the remaining 6100 acres, or 2.9 per cent. of the catchment area, it is estimated that only 850 acres, or 0.4 per cent. of the whole watershed is now under cultivation and might be damaged by the proposed works.

Even in the areas where the surface moisture in the soil would be decreased by lowering the water-table, the land would be no less valuable for most crops. Perhaps some vegetables that require a great deal of water could not profitably be raised there; but other crops, equally valuable, could be cultivated.

The general truth of the above deductions, that no damage would result where the ground is far above the water-table, is well shown on Sheet 152, Acc. L 692. All the damage cases that have been brought against The City, in Queens and Nassau counties, for lowering the ground-water, have been located on low lands near the driven-well stations and in the valleys of the streams. The vast acres of profitable truck farms in western Long Island within half a mile of the Brooklyn ground-water works that have suffered no injury whatever from the lowering of the ground-water, is sufficient refutation of the objections of the Suffolk County agricultural interests to the diversion of the proposed ground-water supply.

APPENDIX 14

LOCAL USES OF WATER IN SUFFOLK COUNTY

BY WALTER E. SPEAR, DIVISION ENGINEER

In diverting the ground-waters of Suffolk county, New York City must recognize the priority of right of this county to all water that is required there for local uses. Water is now used in Suffolk county for domestic supply, street and lawn sprinkling, various small manufacturing uses, steam-power, wash water, etc., and the flows of many streams are still utilized for water-power. It is estimated that the total amount of water now developed within the proposed Suffolk County watersheds is as follows:

	Million Gallons per Day
Public water-supplies (maximum ground-water pumpage of local water-works in summer months)...	5
Steam-power, wash water, and other small commercial uses (surface and ground-waters from private plants)	1
Water-power (average flow of streams that may be utilized)	80
Total amount used	86

The water now used for public supply, steam-power, wash water, and similar commercial uses, could not be diverted without seriously interfering with the health and prosperity of these Suffolk County towns, and these waters would necessarily be supplied by New York City should the operation of the proposed collecting works interfere with the present sources of supply. It does not appear at all necessary, however, to replace in the streams any surface-water that is now used for water-power. The falls at these water-power plants are low, and the entire amount of power developed is insignificant. This power could, at small expense, be replaced by steam-power or perhaps by electric power from the central power-station of the proposed collecting works.

PUBLIC WATER-SUPPLIES

As ground-water exists everywhere in the gravels beneath the surface in Suffolk county, abundant supplies of water for domestic uses and irrigation have been easily obtained by sinking a well a short distance into the ground. Much of the population within the proposed watersheds, probably over 50 per cent., is still supplied by small driven or dug wells near their dwellings and farm buildings. There are no sewerage systems in the Suffolk County villages and the disposal of sewage and household wastes in the ground has made the waters within the villages unfit for use, and the larger villages are supplied by local water-works.

Public water-supplies have been established within the proposed catchment area, through private enterprise, at Amityville, Babylon, Bayshore, Patchogue, Quogue and Riverhead. The ownership of these plants, their yield, and the villages supplied from each station are shown in the following table:

SUFFOLK COUNTY WATER-WORKS

Location of Station	Owner of Works	Villages Served	Pumpage in Gallons per Day	
			Maximum	Minimum
Amityville..	Amityville Water Company......	Amityville................	170,000	40,000
Babylon....	Sumpwams Water Company......	Babylon..................	380,000	160,000
Bayshore...	Great South Bay Water Company.	Bayshore, Islip and East Islip....................	2,000,000	600,000
Patchogue..	Great South Bay Water Company.	Patchogue, Blue Point, Bayport and Sayville........	1,564,000	900,000
Quogue....	Quantuck Water Company.......	Quogue, East Quogue, Westhampton and Westhampton beach..............	900,000	20,000
Riverhead..	Riverhead Water Works Company.	Riverhead................	10,000	10,000
Total......			**5,114,000**	**1,730,000**

Description of Water-Works

The above plants are briefly described in the following pages, and photographs of the larger plants follow this appendix. (Plates 19 to 22, inclusive.)

AMITYVILLE

The water-works system in Amityville was built in 1893 by the Amityville Water Company, and has since been extended from time to time to keep pace with the population.

The pumping-plant of these works is located in the basement of a brick building owned by the Electric Light Company. The plant comprises two half-million-gallon Knowles compound duplex, non-condensing pumps usually run at 80 per cent. of rated piston speed. The pumps are run by steam furnished by the Electric Light Company, and the pumping is usually done at night while the lighting plant is in operation, the same force running both plants. The boilers operating the two plants are two E. P. Hampson & Co. horizontal return tubular boilers of 85 H.P. each and one new 150-H.P. boiler of same pattern made by McEwen Bros. of New York.

The force employed on the pumping and lighting plants consists of a chief engineer, one assistant engineer and one fireman. The two companies, while not identical, are composed largely of the same stockholders.

The supply is taken from two 6-inch driven wells 40 feet deep, whose yield is but little in excess of the demand, and is pumped to a standpipe 20 feet by 125 feet of 293,000 gallons capacity, located near the pumping-station. The maximum pumpage of this plant in summer is about 170,000 gallons, while in winter the minimum is about 40,000 gallons per day. The population of Amityville in the summer is said to be about 3,000 and in winter 2,500.

The fire service is provided through 52 double nozzle hydrants, 5 of which are old Holly hydrants, 6 Glamorgan, and 41 Eddy. The distribution system is now 7.57 miles long, including all extensions to date. The private service comprises about 200 consumers, some of whom use the water only during the summer months. Water is also furnished for street sprinkling for a nominal consideration.

BABYLON

The water-works at Babylon were built in 1893 for the Sumpwams Water Company. The supply is obtained from driven wells, two 8-inch driven in 1893, two in 1898 and two later, making six in all.

The station, which is located in the northeasterly portion of the village on Smith street, 800 feet north of the railroad, was constructed on the Acme system, patented by W. E. Worthen and was built by Oscar Darling. The pumping-plant consists of one 12-inch by 18½-inch by 10½-inch by 10-inch, and one 8-inch by 12-inch by 7-inch by 10-inch Worthington

compound duplex engine, with a total capacity of 2,000,000 gallons per day. The air-compressors in the engine room, one 9½-inch by 8-inch by 8-inch duplex and one 7-inch by 6-inch by 7-inch duplex, provide pressure in the system when the pumps are not working. Normally, the air pressure is carried at 110 pounds and water pressure at 45 pounds. Regulators are provided so that by the addition of weight to levers air pressure may be increased on storage tanks, and the normal water pressure increased for fire service. Steam is provided by two horizontal return tubular boilers of 80 H.P., each built by the Ames Iron Works Co. with brick stack and feed water heater.

The storage system consists of two vertical water-tanks and two horizontal tanks resting on the ground and housed in a building adjoining the engine room. Two compressed air tanks, 17 inches by 18 feet, are also in this building and act as receivers for air-compressors.

The distribution system comprises eight miles of mains with 50 hydrants for fire service. The population of Babylon is estimated to be in summer 4,000 and in winter 2,500. The maximum pumpage of these works is estimated to be in summer 380,000 gallons, and the minimum in winter 160,000 gallons. Private service includes about 350 consumers, some of whom use water only during the summer months.

BAYSHORE

The water-works system in Bayshore, which is owned by the Great South Bay Water Company was built in 1889-90 in Bayshore, and afterward extended to Islip and East Islip. The supply is taken from twenty 5-inch driven wells on Fifth avenue about a mile north of the village. The supply was formerly taken from driven wells on low ground on the north side of the main street of the village, but was so impregnated with iron or manganese that this site was abandoned for the present one.

The pumping-plant at this station, which is a small frame structure, consists of a pair of 2,500,000-gallon compound duplex Knowles pumps, formerly used in the old station. Steam is supplied by one 40-H.P. Hodge boiler, and one new 100-H.P. Erie City boiler, both of the return tubular type. The small boiler is soon to be removed and replaced with a larger one. Both pumps are condensing, using a jet con-

denser, placed between the two engines. The force employed consists of one engineer and one fireman, besides the superintendent, whose time is divided between this plant and that at Patchogue.

The supply is pumped to a stand-pipe, 20 feet by 150 feet, with a capacity of 350,000 gallons, near the old station.

The distribution system comprises about 16 miles of mains, and is extended through Bayshore, Islip and East Islip. The population of the villages served by this system is estimated to be as follows:

Bayshore	4,000
Islip	1,500
East Islip	1,000
Total estimated population	6,500

The maximum pumpage of this station in summer is about 2,000,000 gallons, and the minimum in winter about 600,000 gallons. Fire service is provided through 148 hydrants of the double nozzle type, placed as follows: In Bayshore 84, Islip and East Islip 64 hydrants. The private service comprises about 700 taps.

PATCHOGUE

The water-works in Patchogue are also owned by the Great South Bay Water Company, and were built in 1867 in Patchogue, and later extended to the villages of Blue Point, Bayport and Sayville. Supply is obtained from driven wells at the pumping-station, situated near the west end of the village, and 600 feet south of the South Country road near the outlet of the West lake. The supply is now being augmented by the addition of six 10-inch wells, which are being sunk by the Hudson Engineering Company.

The original Holley pump at this station has been removed, and a new 2,500,000-gallon Worthington compound duplex pump installed in its place. The old 2,500,000-gallon Worthington of similar pattern is still in use, giving a total pumping capacity of 5,000,000 gallons per day. Steam will be furnished by a new Babcock and Wilcox tubular boiler, which is now being installed, after which the old boiler now in use is to be removed. The force employed consists of one en-

gineer and a fireman only, there being no outside men employed except as special occasion may require. This plant is in a brick building somewhat too small for the plant to be operated and is equipped with a brick stack.

The water is pumped to a stand-pipe 115 feet high, with a capacity of 270,000 gallons. This pipe was originally 100 feet high and recently 15 feet more were added.

The company has recently purchased additional real estate, including about 20 acres about the West lake, and six acres south of the South Country road, giving them probably about 30 acres in all, which will thoroughly protect the supply.

The distribution system comprises the greater part of Patchogue, Blue Point, Bayport, Sayville, and West Sayville, with 19 miles of mains. The population of the villages served by this system is estimated as follows:

Patchogue	5,000
Blue Point	500
Bayport	800
Sayville and West Sayville	2,500
Total estimated population	8,800

The maximum pumpage of these works has been 1,564,000 gallons per day in the summer, while the minimum, in winter, is 900,000 gallons. Fire service is provided by means of 165 double nozzle hydrants located as follows: Patchogue 64, Blue Point 26, Sayville and Bayport 75 hydrants. The private service comprises 750 taps, of which 450 are in the village of Patchogue.

QUOGUE

The works in Quogue were built in 1903 for the Quantuck Water Company, by L. J. Richardson of Oswego, New York. They are owned by local residents.

The supply is obtained from driven wells located on the west side of Quantuck creek, about 1800 feet north of the South Country road. These wells, eight inches in diameter and six in number, were put in when the works were built, and two additional 5-inch wells have since been sunk and connected. Depth of wells is said to be 40 feet. The pumping-plant consists of a pair of Rumsey double acting triplex power

pumps, driven by a pair of 40-H.P. Olin gas engines; also a smaller Rumsey triplex power pump, driven by a separate gas engine and used during the winter months when the pumpage is small. The capacity of the larger pumps is 762 gallons each per minute, while that of the small one is 175 gallons per minute. The total daily capacity of the larger pumps is about 2,000,000 gallons per day. The pumping-station is a brick building about 26 feet by 60 feet with concrete floor. The company employs one man as engineer and superintendent, who lives in a house adjoining the plant.

The supply is pumped to a stand-pipe located near the pumping-station, and the stand-pipe, 20 feet by 100 feet, has a capacity of 235,000 gallons.

The population of the villages served by this plant is estimated to be as follows:

	In Summer	In Winter
Quogue	2,000	400
East Quogue	1,800	500
West Hampton	1,500	400
West Hampton beach	2,000	500
Total estimated	**7,300**	**1,800**

The system comprises 16 miles of mains, covering the settled portions of the above villages. The maximum pumpage in summer is estimated to be 900,000 gallons and the minimum in winter as low as 20,000 gallons.

Fire service is provided through double nozzle fire hydrants 124 in number, 99 of which are in use. The 25 hydrants in East Quogue are not used, there being no fire district established there. The private service includes about 300 consumers, some of whom have as many as five taps in the mains. The population served is mostly summer residents and their houses are closed during eight months of the year, so that the service in the winter amounts to very little.

RIVERHEAD

The water-works system in Riverhead was built by C. A. Lockwood of Jamaica in 1892, for the Riverhead Water Works Company. The supply is taken from driven wells, one 6 inches in diameter, 305 feet deep, and one 8 inches in diameter, 225 feet deep, and is pumped to a wooden tank at the top of

the "Tower" mill on Peconic avenue. The capacity of this tank is rated at 40,000 gallons. The supply is pumped by a 250,000-gallon Knowles pump located in the mill, and operated by water-power when power is available, and at other times by either or both of the two gas engines there. The water-power is variable, owing to the tide backing up on the wheels. There is no regular force employed; the pumps are run by one of the mill hands.

The population of Riverhead is estimated to be about 3,000 at the present time, and is not subject to much fluctuation between summer and winter. The distribution system comprises about four miles of mains and the private service is about 150 consumers. Fire service is provided through 12 old Holley hydrants set on the streets, and 2 Corey hydrants for private use.

Substitution of Local Supplies by Water from the Proposed Aqueduct

The waters from these local stations are quite satisfactory in quality, although some of them are higher in dissolved mineral matter than is desirable. The supply from the proposed Suffolk County works would be better in quality than any of these supplies, and would always be more thoroughly protected from pollution. Should the proposed diversion of the Suffolk County ground-waters to New York City deprive any of these local works of their present sources of supply, it would not be expensive to re-locate the present pumping-stations on the proposed line of collecting works so that water from the aqueduct would flow directly to the pump-wells, and be delivered by the local stations under pressure to the distribution systems. The water could be supplied to these towns at the cost of its development.

Probable Future Consumption of Suffolk County

The consumption of the villages now being served with a public water-supply is seen to be at a maximum, 5.1 million gallons per day, and does not average over three million gallons daily. The consumption of water in the districts served by these local water-works will increase, however, in the future, and a larger amount of water than the above must be supplied at the end of, let us say, 50 years.

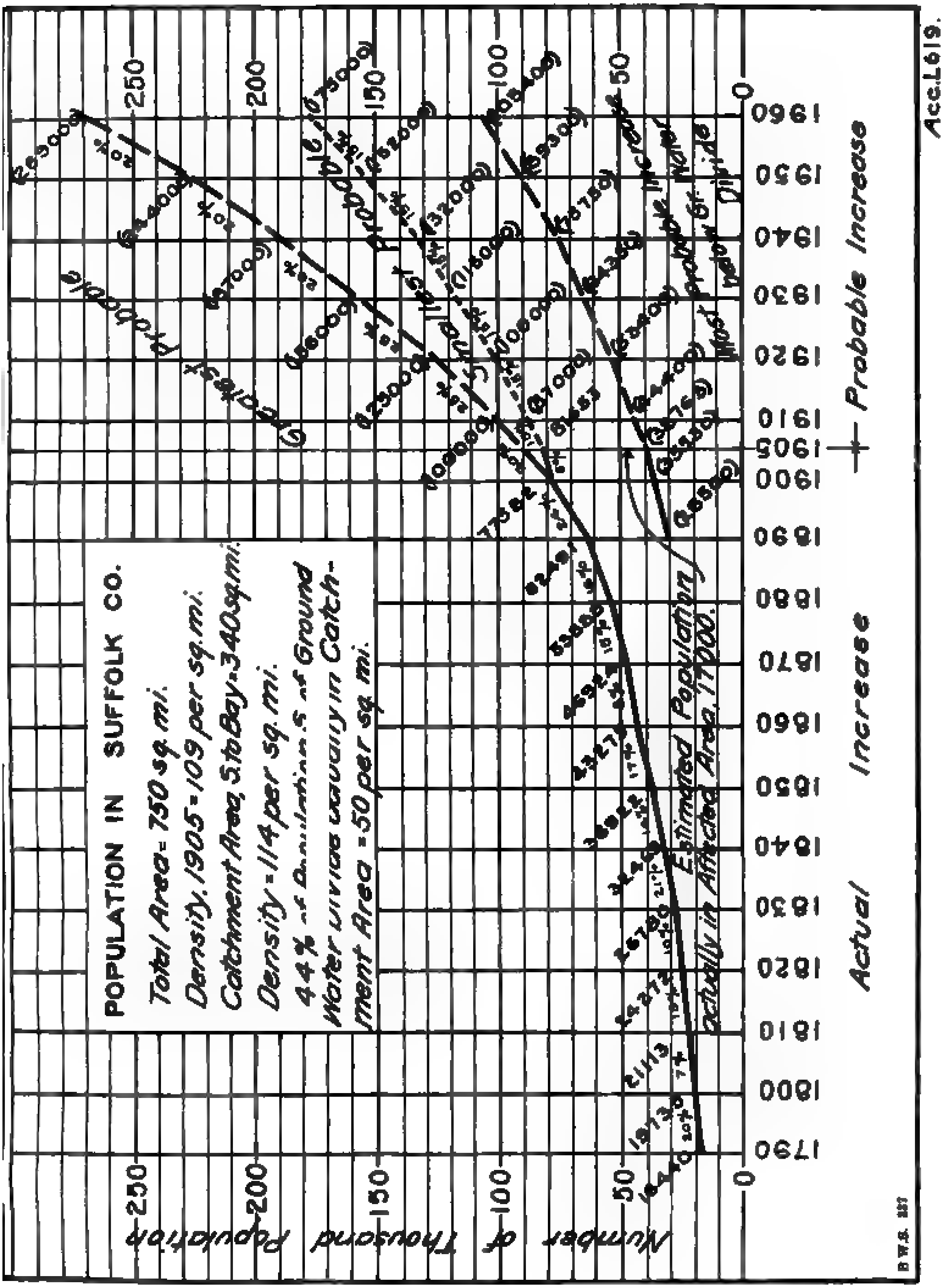
At present the population within and south of the watershed is about 39,000, but this includes the communities in central Suffolk county whose water-supply would in no wise be interfered with by the proposed collecting works. Probably not over 30,000 people are resident within the areas supplied by the present local water-works. Sheet 150, Acc. L 619, shows the present and probable future population of Suffolk county. It appears reasonable to estimate that in 50 years, the population within the watershed that it would be necessary to supply, would not exceed 100,000, and at the largest probable per capita consumption, including water for all public, domestic and manufacturing uses, this population would not consume over 15 to 20 million gallons at the end of 50 years. This amount of water is insignificant in a total supply of 250 million gallons per day and considering the conservative estimate of yield that has been accepted for the Suffolk County watersheds, the reservation of 15 or 20 million gallons per day should not decrease the net supply that can be delivered to New York City when as large a supply as this is required.

WATER FOR MANUFACTURING PURPOSES

A small amount of water for various commercial purposes is supplied from private sources in Suffolk county, and is not included in the consumption of the public water-works.

The principal users of water for industrial purposes are as follows:

	Gallons per day
Patchogue Manufacturing Company; bleaching lace curtains	500,000
Patchogue Manufacturing Company; seven 150-H.P. boilers	25,000
Hygeia Ice Company (6 months), Patchogue	50,000
Patchogue Electric Light Company, boilers	12,500
E. Bailey & Sons (Lumber), boilers, Patchogue	15,000
Hallett Brothers, flour mill, Riverhead	15,000
Hygeia Ice Company, Sayville, C. M. Rogers & Co.	10,000
Estimated for electric light companies in south shore towns, Patchogue, Bayshore and Babylon	50,000
Other small factories, estimated	10,000
Total amount of water	687,500


POPULATION IN SUFFOLK CO.
Total Area = 750 sq. mi.
Density, 1905 = 109 per sq. mi.
Catchment Area, S. to Bay, = 340 sq. mi.
Density = 114 per sq. mi.
Estimated Population actually in Affected Area, 17000.
Actual Increase
Probable Increase
Number of Thousand Population
Acc. L619.

The larger of the above plants are briefly described as follows:

The Patchogue Manufacturing Co. has a group of brick buildings, mostly erected during the last 12 years, and containing lace machinery. The entire plant employs normally about 500 hands. They have ten 150-H.P. boilers of which they use seven only at the present time for 24 hours daily. This plant uses the water of the Patchogue lake for bleaching and boiler feed. The town supply is not usually consumed for boiler purposes, though a connection exists for this purpose. A photograph of the Patchogue Manufacturing Co.'s plant is shown on Plate 23.

E. Bailey & Sons have a large brick mill, and do a general lumber, planing, sawing and turning business. The plant has a water front on Patchogue river and a railroad connection. The mill is run by two 125-H.P. boilers, working nine hours daily, and uses about 15,000 gallons of water per day, taken from a 6-foot dug well, about seven feet deep.

The Hygeia Ice plant of Patchogue, owned by Welz and Zerweck, Brewers, of Brooklyn, is equipped with one 60-H.P. boiler and runs six months of the year. The plant has a maximum output of 18 tons of ice daily. The water is taken from an 8-inch well 38 feet deep, and city water is only used in case of emergency. This plant is at the east end of the village south of the Long Island railroad.

The Hygeia Ice Company of Sayville is owned by C. M. Rogers & Co., and is located south of the Long Island railroad, one quarter of a mile east of the railroad station. This plant is being enlarged to a daily capacity of 18 tons of ice, and will be operated by the present 40-H.P. Atlas boiler, and a new 80-H.P. boiler. Water is taken from three 2-inch wells on the property, but a connection exists with the water-works for emergency use.

The present use of water for manufacturing purposes is evidently small and there is little likelihood of any large increase in manufacturing in Suffolk county. There are no advantages in these towns to tempt a manufacturer to locate there, except low wages and possibly freedom from labor troubles. Labor is not abundant, however, and the towns which are encouraging the commuter and the summer visitor would not seek large industrial enterprises and the attendant factory population.

The water necessary for all future industrial uses would be supplied from the public mains, and the per capita consumption here assumed for the future population is ample to cover such uses.

WATER-POWER

Water-powers have been developed in the past on all the larger streams in Suffolk county and many are still used to run sawmills, grist-mills and electric lighting plants. Many of the old water privileges doubtless date back to the period when large bounties were offered for the establishment of water-powers. At the present only 8 water privileges are in use among 11, where buildings and equipment still exist.

Babylon Whip Factory and Sawmill

The Hendrickson ice cream factory, together with a small sawmill and whip factory, are located on the west side of Sampawams creek at the outlet of Sutton lake on the easterly boundary of Babylon at the South County road. The plant is said to be owned by Mr. C. S. Hendrickson.

The whip factory is a very old building, and the ice cream factory has been built some years. The water-power is utilized by the sawmill and whip factory, the ice cream plant being operated by a 25-H.P. steam engine, using town water for the boiler.

Mr. Bunce (Chas. Wood & Co.) leases the sawmill and whip factory, and sublets the latter to D. C. Rickett, who employs five hands and turns out 1000 whips per day.

Doxsee's Mill, Islip

A small mill owned by Mrs. J. H. Doxsee is a part of an estate of 30 acres fronting on South Country road, extending north as far as the railroad. The fall at the lower pond is utilized on a turbine wheel for private purposes, sawing fire wood, thrashing grain, and running a grindstone. There is an additional fall of three feet at the small pond, 1200 feet north of the one described, which is not used for power purposes.

Hawkins Lake Paper-Mill, Islip

This old mill has been abandoned for many years. It is situated on Orowoc creek, west of the village of Islip at the north side of South Country road. Both the building and

the flumes are in decay and have little value. The westerly half of the lake is said to be owned by Mr. Wm. H. Moffitt, the easterly half by Mrs. P. J. Hawkins of Islip.

Paper-Mill at Canaan Lake, Patchogue

This mill is on the east branch of Patchogue creek about one mile north of the village of Patchogue and has not been in operation for some years. Two years ago it was sold to the Forest Lakes Realty Company with the old mill buildings, the machinery and most of the pond above.

Swezey's Mill, East Patchogue

This mill is located on the South Country road at the outlet of the pond on the Swan river, and serves at present for a grist-mill. It is claimed that there is water enough to run one of the large wheels rated at 53 H.P. for an entire working day, and the capacity of the mill is placed at 30 bushels of grain daily. One-half the pond is said to still belong to the Robinson family in East Patchogue, and is used by them for cutting ice.

Sawmill on Mud Creek, East Patchogue

This mill, which is owned by the Robinsons, has not been in operation for years, and is much dilapidated.

Grist-Mill and Sawmill at South Haven

This mill is situated at the outlet of the pond on the Carman's river, just above the South Country road, and belongs with the surrounding land, and the pond above, to the Suffolk club. The sawmill has an under-shot wheel 2 feet by 10 feet rated at 25 H.P. which is said to do about $750 of business annually. The grist-mill has two turbines 24 and 16 H.P. respectively, and one old 12-H.P. tub wheel. This mill does about the same amount of business as the sawmill.

Saw and Grist-Mill at Yaphank

This mill belongs to Mrs. Mary Gerard of Patchogue, and runs intermittently as business requires.

Saw and Grist-Mill at Speonk

This mill is on the east branch of Seatuck creek. The lessor, Mr. Maynard, of Speonk, operates both saw and grist-

mills. The first is run by a small turbine, the latter by an under-shot wheel.

Tower Grist-Mill, Riverhead

This is located at the head of tide-water on the Peconic river, and is owned by Mr. F. L. Griffing. Two turbines, 15 and 40 H.P., respectively, and an auxiliary steam-pump, operate this mill. At high tide the fall of this privilege is small and the mill is operated by steam-power.

Hallett Brothers Grist-Mill, Riverhead

This is on the lower dam at Riverhead opposite the tower mill above described. It is operated by two turbines having a total capacity of 50 H.P. at maximum head, and supplemented by one 25-H.P. engine and boiler. Like the tower mill, the fall is small at high tide. Hallett Brothers have another new mill nearby operated entirely by steam-power.

Riverhead Electric Light Company

This plant is located on the upper dam about 1½ miles above the village of Riverhead, and is equipped with one 24-inch and one 36-inch Hercules turbine, and one 40-inch McCormick turbine. No auxiliary steam-power is required.

There is an old woolen mill at this dam, which has not been running for 10 years, since farmers in the vicinity have given up the raising of sheep. A full set of machinery, which is still in this mill, was formerly operated by an over-shot wheel.

Both plants at this dam are owned by the estate of J. R. and J. H. Perkins.

In Table 44, are presented the average flow of the streams on which power-plants exist, the minimum monthly discharge of these streams, the storage available in the ponds above, the falls acting on the wheels, and the probable amount of power that could be developed in a 10-hour day. For comparison with the rated power equipment of these plants, a rough estimate has been made of the reasonable power development up to the eighth driest month of 1907.

The equipment of most of these small mills is made in excess of an economical development for 10-hour service. The intermittent character of the work at these small mills should, however, be considered. A large amount of power may, of course, be developed from pond storage for a few hours. In

one of these country grist-mills, each stone is run by an independent wheel, and seldom are they all operated together.

The total equipment now in use aggregates about 400 H.P., but the water available at these water privileges during the dry summer months of the year, which is estimated as 64.5 cubic feet per second or 42 million gallons per day, would not develop on these low falls over 100 H.P. during a 10-hour day.

The water available at all the mills where equipment exists, did not amount to but 80 cubic feet per second or 52 million gallons per day in the summer months of 1907, and this would not furnish but 125 H.P. in a 10-hour working day.

An economical development of the waters at the privileges now being used would not call for a total equipment of much over 220 H.P. for a 10-hour working day.

The replacing of this water-power would not be a serious item, should the proposed diversion of the ground-water in Suffolk county reduce the flow of any of these streams at the above mills.

Photographs of many of these mills are shown on Plates 23 to 30, inclusive.

PLATE 19

Amityville water-works pumping-station at Amityville.

PLATE 20

Sumpwam's Water Company pumping-station at Babylon

PLATE 21

Great South Bay Water Company pumping-station at Bayshore.

PLATE 22

Great South Bay Water Company pumping-station at Patchogue.

PLATE 23

Patchogue Manufacturing Company lace-mill on South Country road at Patchogue river.

PLATE 24

Ice cream and whip manufactory at Sutton's pond, South Country road, Babylon.

PLATE 25

Hawkin's paper-mill on South Country road, at Orowoc creek, Islip.

PLATE 26

Paper-mill on Patchogue river at Canaan.

PLATE 27

Grist-mill on South Country road at Swan river, East Patchogue.

PLATE 28

Grist-mill and sawmill on South Country road, at Carman's river, South Haven.

PLATE 29

Sawmill on Carman's river at Yaphank.

PLATE 30

Grist-mill and sawmill on South Country road, at Seatuck creek, Speonk.

APPENDIX 15

MAINTENANCE OF SURFACE PONDS

BY WALTER E. SPEAR, DIVISION ENGINEER

The many fresh-water ponds in southern Suffolk county form one of the most attractive features of the villages and estates along the south shore, and it is recognized that no payment could be made that would properly compensate their owners for the diversion of their waters, should the collection of the proposed ground-water supply seriously lower the surfaces of these ponds and deprive the owners of their enjoyment. It is proposed, therefore, in the operation of the Suffolk County works, that these ponds shall be maintained in their original volume and purity. There are several ways of doing this.

Where the ponds are near the proposed collecting works, sufficient water might be diverted from the main aqueduct into them to maintain their surfaces at, or but little below, the spillway level. The only loss of water resulting from this diversion would be the seepage through the down-stream portion of the ponds when these are on the seaward side of the proposed collecting works. The remainder of the water delivered to these bodies of water and not lost by evaporation would naturally return through the earth to the collecting works. Water delivered to ponds on the up-stream side of the collecting works would all return, with the exception of the evaporation losses.

Many small ponds along the south shore are so far from the line of the proposed works that their levels would readily be maintained by the ground-water seepage from their immediate watersheds, without the flow from the upland catchment area. Others, however, at some distance from the collecting works, are now held by high embankments at an elevation somewhat above the normal ground-water surface by the flow in the tributary surface streams. In many of these ponds, the beds could perhaps be dredged out and their water surfaces maintained at a somewhat lower level. The spillways would, of course, be lowered, and the original area of water surfaces with clean gravel slopes retained. Such ponds, when lowered a few feet, would be maintained for the most part by the surface run-off and seepage from their

local catchment areas. There would be ample opportunity to dispose of the material dredged from these ponds in the low ground and stagnant pools of the swamps and marshes nearby to the advantage of the entire countryside.

If it were not practicable, however, to lower the level of some of these ponds, they could be maintained by one or two wells, and a small pumping-plant operated like the remainder of the system from the central power-station. These wells would be located a short distance upstream from the heads of these ponds, and sufficient water to keep up their levels could be drawn from the ground on a lower lift and at less expense than the same amount of water supplied from the aqueduct. Most of the water delivered from these wells would be drawn back through the bottom of the pond and a continuous circulation could be obtained that would keep the waters of these ponds clean and wholesome.

Experiments at Massapequa

Under the terms of the purchase of the Massapequa lake, which is the pond below the Massapequa driven-well station and gallery in eastern Nassau county, the Department of Water Supply is obliged to maintain this pond at an elevation near the spillway level. To effect this, water from Massapequa stream is allowed to flow from the supply pond north of the works into this lake in sufficient quantity to make up for the seepage through the bottom.

The relation between Massapequa lake and the ground-water collecting works at Massapequa is shown on Sheet 151, Acc. L 644. The water that was allowed to escape from the supply pond to maintain the level in the lower lake was measured last year by two weirs, which were constructed in the stream by the Board of Water Supply, and which are shown on Sheet 151, Acc. L 644. When no water escaped from the spillway of Massapequa lake, these weirs gave a measure of the amount of seepage both through the stream bed and through the bottom of the lake. The ground-water contours indicate some loss through and around the dam at the lower end of the lake and a general movement of the ground-water toward the driven-well station and the infiltration gallery.

The weirs, test-wells and pits, that were put in to determine the ground-water elevations, were not completed until the first of December, and the experiments were carried on

but a few weeks before freezing weather and heavy rains set in, and all diversions to the lake were discontinued. The observations were consequently somewhat meagre, and it would be desirable to continue this work during the present year. The results now available, however, give some idea of the amount of seepage that would take place through the bottoms of other Long Island ponds when the ground-water table is lowered about them. These results are presented in Table 45, with the rainfall and the pumpage at the Massapequa works. The driven-well station was started up on November 29, after a shut down of nine days. The gallery was pumped constantly through November, at an average rate of 8.9 million gallons daily.

It is evident, for one thing, that the losses through the bed of the stream between the weirs were much larger than those through the bottom of the lake. The movement of water in the stream prevents the accumulation of humus that has covered the bottom of this lake with a fairly tight layer of black muck. The measured loss through the bottom of the lake, correcting for evaporation from the lake surface, was on one day as high as 9,000 gallons per day per acre, although both wells and gallery were shut down. The loss was ordinarily from 5,000 to 6,000 gallons per day per acre, but to be on the safe side, it would seem reasonable to estimate upon an average loss of 10,000 *gallons per day per acre from Massapequa lake to cover larger losses during dry summer months.

The seepage through the bottom of the stream between the two weirs averaged from 40,000 to 1,920,000 gallons per acre per day. The maximum occurred on December 15, on starting up the driven-well station after being shut down four days. This interval gave the ground-water beneath the stream an opportunity to recover and, on starting up, the sand below the stream bed was doubtless saturated, and the seepage to the wells was then a maximum. As the ground-water surface was lowered in the following days, the percentage of saturation in the sands beneath the stream bed became constantly less and the downward flow naturally decreased. The average seepage through the stream bed, for the entire period of observation was something over 300,000 gallons per acre per day, or five or six times that through the bed of the lake.

*Subsequent observations at Massapequa lake in October, 1908, after several months of dry weather showed the total loss to amount to 13,000 gallons per day per acre, of which it was estimated that 3,600 gallons per day were lost by evaporation and 9,400 gallons per day per acre by percolation through the bottom of the lake.

TABLE 45

Seepage from Massapequa Stream and Lake

Date December	Yield of Massapequa Collecting Works in Million Gallons per Day			Daily Seepage Through Bed of Stream 0.44 Acre		Daily Seepage from Lake 37.35 Acres		Rainfall as Observed at Hempstead Storage Reservoir Inches
	Driven-well Station	Infiltration Gallery	Total	Total Gallons	Gallons per Acre	Total Gallons	Gallons per Acre	
1	3.60	7.96	11.56	......	......	......	......	....
2	3.50	8.46	11.96	......	......	......	......	....
3	1.33	7.70	9.03	34,510	78,200	204,550	5,500	0.07
4	Shut down	8.55	8.55	35,130	79,600	224,800	6,000	0.09
5	" "	8.90	8.90	32,340	73,300	......	......	....
6	2.69	8.33	11.02	28,620	65,900	......	......	....
7	3.41	8.20	11.61	125,200	283,500	194,320	5,200	....
8	3.23	8.60	11.83	70,700	160,200	194,320	5,200	....
9	3.59	8.05	11.64	18,140	41,100	194,320	5,200	....
10	0.90	3.44	4.34	......	......	......	......	0.99
11	Shut down	Shut down	......	177,760	403,000	185,120	5,000	....
12	" "	" "	......	31,300	71,000	315,800	8,500	....
13	" "	" "	......	131,180	297,500	342,500	9,200	....
14	" "	" "	......	404,820	918,000	Lake wasting		1.12
15	2.92	" "	2.92	837,140	1,920,000	" "		0.03
16	3.50	" "	3.50	355,340	805,000	" "		....
17	3.50	" "	3.50	60,300	136,600	" "		....
18	3.41	" "	3.41	75,300	171,000	" "		....
19	3.50	" "	3.50	41,680	94,500	" "		....
20	3.14	" "	3.14	104,300	236,500	" "		....

Flow over north weir took place during period covered by observations, except on December 9 and 10
There was no flow over south weir on December 3, 4, 7, 10 and 12
Total estimated evaporation allowed from stream, 580 gallons per day
Total estimated evaporation allowed from lake, 48,680 gallons per day
Allowance made for rainfall

The results show that about as much water was lost through the small surface of the bed of the stream as through the larger lake bed, and this suggests that some water might have been saved by delivering the water to the lake from the supply pond through a line of vitrified pipe, and thus preventing the seepage through the stream bed.

Possible Seepage from Suffolk County Ponds

The ponds in Suffolk county are much the same as Massapequa lake; they are similarly situated and their bottoms are covered with a bed of black muck that would make them equally tight. These ponds which, like Massapequa lake, are near the proposed collecting works, might require as much as 10,000 gallons per day per acre to keep their waters at the hight of their spillways. Many of the ponds are, however, as much as a mile or more from the proposed collecting works, and it is unlikely that more than 5,000 gallons per day per acre would be lost from them, even at their present levels.

In Table 46 all the Suffolk County ponds along the south shore that might possibly be lowered by the proposed collecting works are tabulated with their areas and distances from the works. Judging from the experience at Massapequa, the volumes corresponding to the seepage at Massapequa lake need not be supplied during many of the winter and spring months when the shallow ground-waters about them are high, as a result of the winter rains, and there is an ample flow in the streams. Probably, on the average, these pond levels would need to be maintained artificially during the dry weather of about 8 to 10 months of the year. When heavy rains occur, even in the summer months, the surface run-off from the immediate watershed would often be sufficient for the purpose. It is estimated that only about 3 million gallons per day would be required in the driest months, and ample allowance has been made in the estimates of pumping to provide this amount of water, although not as much as this would be required if the levels of these ponds were lowered.

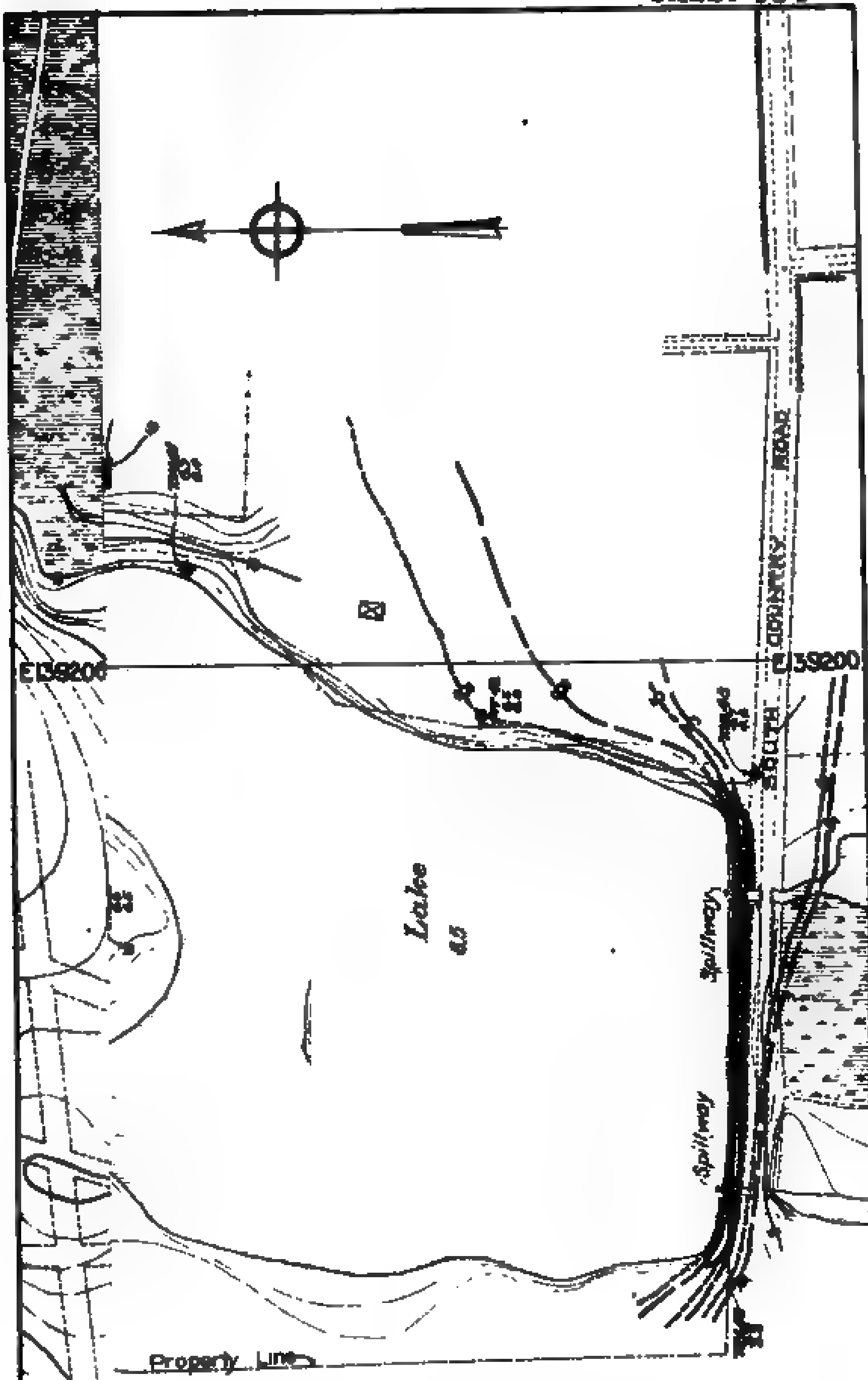
Maintenance of Ponds

The adjustment of the ponds to meet lower ground-water levels, and the location and design of small local pumping-stations that it might be desirable to build near these ponds to keep up a circulation through them, could best be made

TABLE 46

Areas, Elevations and Distances of Suffolk County Ponds on Which Board Estimates of Probable Supply to Maintain Their Levels

Pond	Approximate Area in Acres	Elevation of Surface Feet	Distance from Line of Proposed Collecting Works Feet
Amityville creek	10.1	9.1	S 4,400
Gilmore's pond (Santapogue)	9.7	3.4	S 6,200
Southard's pond (Carll's)	25.3	16.1	S 0
Argyle lake (Carll's)	22.7	6.6	S 4,800
Sutton's pond (Sampawam's)	17.2	7.0	S 5,200
Wagstaff (Willetts creek)	8.1	4.5	S 7,000
John Moby creek	7.3	9.8	S 4,300
Laurence creek	5.0	11.3	S 4,500
Penataquit	11.6	9.0	S 3,800
Orowoc	4.7	5.7	S 6,000
Doxsee pond	22.3	7.2	S 6,000
Champlin	21.8	10.3	S 4,800
Cutting's	13.2	8.1	S 600
South Shore Sportsmen's Club ponds			
West branch, upper	14.3	7.7	S 0
West branch, lower	3.7	2.0	S 700
East branch	14.3	7.0	S 0
Roosevelts			
West branch, Browns creek	10.6	6.5	S 1,700
East branch, Browns creek	9.2	7.4	S 2,700
West lake (Tuthill creek)	13.8	9.1	S 2,000
Patchogue lake	51.2	10.7	S 0
Swan River pond	25.8	10.6	S 1,500
Mud creek, Robinson's pond	11.5	6.0	S 2,800
Suffolk club (Carmans river)	16.0	7.6	N 500
Forge River ponds	12.2	8.5	S 1,000
Terrell's river	15.2	9.3	S 1,800
Long Island Club, Seatuck creek	32.8	9.2	S 1,000
East branch, Seatuck creek	6.3	9.1	S 2,600
Speonk river	6.3	6.4	S 4,000
Beaverdam creek	14.7	7.4	S 2,400
Quantuck creek	12.8	3.0	S 4,300
Total	329.5		



City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
AINTENANCE OF SURFACE PONDS
DRAINAGE OF MASSAPEQUA LAKE
BY THE OPERATION OF
ATION GALLERY AND DRIVEN WELL STATION

FEBRUARY 25, 1908

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APPENDIX 16

LEGAL DECISIONS ON DIVERSIONS OF SURFACE AND GROUND-WATERS AND THE AMOUNT OF AWARDS

BY WALTER E. SPEAR, DIVISION ENGINEER

The operation of the Ridgewood system of the Brooklyn Water Works in Nassau and Queens counties, has, in some measure, decreased the flow of the surface streams and depressed the water-table in the vicinity of the collecting works, and some large awards for consequential damages have been paid by The City during the last 10 years. The amount of these awards has, however, been much exaggerated. Because of some misgivings that have been expressed regarding the probable amount of water damages that might result from the construction of the proposed Suffolk County works, it has appeared to be worth while to outline briefly the laws regarding the diversion of surface and underground waters, and, more particularly, to show the number of actions that have been brought against The City in Nassau and Queens counties, and the total amount of the awards.

DIVERSION OF SURFACE-WATER

Outside of the lands originally a part of the public domain, the owner of the land in this county has, under the common law, a right in the surface-water that naturally flows through it. The owner may not, however, divert this water from its natural channels through the lands below his property, and, in most states, he cannot pollute the stream and render its waters unfit for the uses of other riparian owners below him.

DIVERSION OF SUBTERRANEAN WATERS

When water moves beneath the surface of the ground in well-defined channels, the laws regarding the diversion of ground-waters have been the same as those relating to surface streams; that is, such underground waters cannot be used or diverted by the owner of the land through which they pass. The natural flow of the water to the lands below, must not be

interrupted, although the owner may make such reasonable and necessary uses of the water as will not interfere with similar uses by others.

If, however, ground-water is moving in unknown channels through the pore spaces of the earth, or is being stored without motion in an underground reservoir, it was formerly held that the owner of the land could appropriate all of these waters for his own use. The Court ruled in an important New York case, Ellis vs. Duncan et al., 21 Barbour (N. Y.), 230:

"The question involved in this controversy, whether the owner of a farm may dig a ditch to drain his land, or open and work a quarry upon it, when by doing so he intercepts one of the underground sources of a spring on his neighbors' lands. . . . In the interruption of a surface current, the injury from a diminution of the water would seem to be palpable, and so far direct that it would originate a valid cause of action. . . . But it is different when the principal stream is partially supplied by underground currents. The owners of the surface soil are not generally aware of their existence and cannot be supposed to have voluntarily acquiesced in any appropriation of them. When they purchase they are ignorant of any obstacle to the free use of their property *ab center ad coelum* and to arrest some valuable improvement, such as digging a well or cellar, draining the land, taking valuable stones from a quarry, or leveling the ground for building or agricultural purposes, because it would cause some consequential, unforeseen, and possible irremediable damage to another, would seem to be unreasonable and unjust."

Recent decisions have, however, limited the use of percolating waters.

Actions Against The City of New York for Damages to Lands

The first suit brought against The City on account of the operation of the driven-well stations, appears to have been that of Van Wycklen vs. the City of Brooklyn, which was tried in 1886. The plaintiff owned a grist-mill near the outlet of Spring creek into Jamaica bay, below the city's works, and obtained power from both the tidal flow and the waters of the creek. It was proven that water had been abstracted from the stream by the Spring Creek pumping-station, and the court held that this was a sufficient cause of action against the city.

This case did not involve the question of ground-water diversion.

In 1898, an important case, that of Smith vs. the City of Brooklyn, 18 (N. Y.), App. Div. 340, created a new and important precedent regarding the diversion of ground-waters. Smith was the owner of land under a small stream tributary to Freeport creek, and a pond in the village of Freeport formed by damming this stream. Both were alleged to have disappeared through the lowering of the ground-water surface in their vicinity by the operation of the Agawam driven-well station about 2000 feet east of the pond. The court reviewed the English and American decisions, and affirmed that the City of Brooklyn was liable for damages because of the ground-water diversion. The decision was upheld in the higher court, 160 (N. Y.), 357, but the reasons stated there, were that the city had caused the diversion of a stream, and no modification was really made in the original laws regarding the appropriation of ground-water.

" That the diversion and diminution of the stream were caused by arresting and collecting the underground waters, which, percolating through the earth, fed the stream, does not affect the question. When the fact was established upon the proofs that the defendant's works and wells had caused, by this subsidence of waters, a diversion of the stream's natural flow in its channel the injury was proved and the plaintiff's cause for action established. Whatever may be the rule with respect to the right of a landowner to use, for any of his purposes, the waters percolating through the earth, and, thereby, to affect the sources of wells or springs upon his neighbor's land, the question is not one which is suggested by the present case. It is one thing to divert and diminish the natural flow of a surface stream, by preventing its usual and natural supply, or by causing, through suction or other methods, a subsidence of its water; it may be another thing to collect and use the waters which percolate through the earth in underground ways and channels without having connection with the supply of a surface stream. The latter question does not demand an answer upon the case before us."

A subsequent case in the same year near the Spring Creek station, Forbell vs. The City of New York, 164 (N. Y.), 522, which involved only the question of ground-water diversion, was decided against The City by the Appellate Court on the

grounds that the collection of water from very permeable strata and the selling of water so obtained, was unlawful, although no surface water was diverted or diminished. It was held in this decision:

"The defendant makes merchandise of the large quantities of water which it draws from the wells that it has sunk upon its two acres of land. The plaintiff does not complain that any surface stream or pond or body of water upon his own land is affected thereby, but does complain and in courts below have found that the defendant exhausts his land of its accustomed and natural supply of underground or subsurface water, and thus prevents him from growing upon it the crops to which the land was and is peculiarly adapted, or destroys such crops after they are grown or partly grown."

"The defendant does not take from his own land simply its natural or accustomed supply or holding, but by means of its appliances and operations it takes and appropriates a large part of the natural and accustomed supply or holding of the plaintiff's land. The case is not one in which, because the percolation and course of the subsurface waters are unobservable from the surface they are unknown, and thus so far speculative and conjectural as to be incapable of proof or judicial ascertainment."

"Before the defendant constructed its wells and pumping-stations, it ascertained, at least to a business certainty, that such was the percolation and underground flow or situation of the water in its own and plaintiff's land that it could by these wells and appliances cause or compel the water in the plaintiff's land to flow into its own wells, and thus could deprive the plaintiff of his natural supply of underground water. . . ."

"In the cases in which the lawfulness of interference with percolating waters has been upheld, either the reasonableness of the acts resulting in the interference, or the unreasonableness of imposing an unnecessary restriction upon the owner's dominion of his own land, has been recognized."

"In the absence of contract or enactment, whatever it is reasonable for the owner to do with his subsurface water, regard being had to the definite right of others, he may do. He may make the most of it that he reasonably can. It is not unreasonable, so far as it is now apparent to us, that he should dig wells and take therefrom all the water that he needs in

order to gain the fullest enjoyment and usefulness of his land as land, either for purpose of pleasure, abode, productiveness of soil, trade, manufacture, or for whatever else the land as land may serve. He may consume it, but must not discharge it to the injury of others. But to fit it up with wells and pumps of such pervasive and potential reach that from their base the defendant can tap the water stored in the plaintiff's land, and in all the region thereabout, and lead it to his own land, and by merchandising it prevent its return, is, however reasonable it may appear to the defendant and its customers, unreasonable as to the plaintiff and the others whose lands are thus clandestinely sapped, and their value impaired."

Under this decision The City was made the technical trespasser on all lands where the water-level was lowered, and the owner of the property could recover for any damages that might be proved to have been caused by such lowering. A rule was laid down later that the damages should be fixed by the reduction in fee and rental or the usable value of the land. Loss of profits could not be included as such, but testimony as to profits was admissible for the purpose of showing to what extent the usable value of the property had been diminished.

In addition to the action for damages to land due to diversion of surface and ground-waters in Nassau and Queens counties, claims have also been made for damages to tidal streams through the diversion of the waters of the entering streams. Under an act of the Legislature, The City of New York paid to the town of Hempstead $50,000, to cover all present and future claims for damages that might be caused to the tidal waters of that town by the diversion of the surface streams. Suits were also instituted by oystermen in Nassau county who claimed that their business was injured by the diversion of the fresh water from the tidal streams. These cases were, however, successfully defended by The City on the grounds that the claimants had no title to the land under the navigable streams, and therefore their actions could not lie.

Other Decisions

In the earlier suits, injunctions have been asked to restrain The City from operating their stations, but the courts have refused such relief, unless The City failed to make permanent settlement for damages caused by the lowering of the ground-water surface.

In a case of two water companies engaged in the sale of water, it was decided that neither had cause for action against the other, as both were abstracting water from the ground and selling it.

The courts have also ruled that where property was disposed of subsequent to the establishment and operation of the ground-water collecting works, no recovery could be made, as the reduction in fee and rental value had been considered in the price at which the property was sold or rented. In several states, it has also been decided that underground waters may not be polluted by industrial refuse or by drainage from privy vaults or cesspools or by salt water.

ACTIONS DUE TO OPERATION OF RIDGEWOOD SYSTEM

The decisions of 1898 (Smith and Forbell vs. City of New York) opened the way for the filing of a large number of claims which are shown in chronological order in the following table:

ACTIONS BROUGHT AGAINST THE CITY OF BROOKLYN, AND THE CITY OF NEW YORK AS ITS SUCCESSOR, FOR DAMAGES DUE TO THE DIVERSION OF WATER BY THE OPERATION OF GROUND-WATER STATIONS, ARRANGED IN CHRONOLOGICAL ORDER

Date of Filing Summons and Complaint	Number of Suits Instituted	Amount Claimed
Prior to 1898	1	$30,000
1898	15	125,000
1899	12	144,400
1900	20	357,000
1901	48	463,811
1902	6	66,000
1903	7	202,200
1904	..	......
1905	11	40,750
1906	11	62,900
1907	2	10,000
Total	**133**	**$1,508,061**

Amount of Claims

So far as possible all suits brought against The City and the disposition of the cases, have been compiled, but some difficulty has been experienced in obtaining the necessary data, and possibly a few have been overlooked. These cases have not only been handled in the branch offices in Brooklyn and

Queens boroughs, but many have been tried by the main office of the Law Department in Manhattan.

The amounts of these claims aggregate about $1,500,000, but the awards have been comparatively small.

Amount of Damages Awarded

The amount of damages awarded to plaintiffs in actions against The City for trespass by lowering the ground-water level, or abstracting water from streams, has varied within comparatively wide limits. The amounts of the awards have been influenced by the location of the property in reference to the pumping-station, by the relative elevation of the water-table, by the data available to The City for defence, by the way in which the case was presented, and by the judge before whom the case was tried. From about 1902 to 1906, the majority of the cases were settled without formal trial, and the awards made during this period were in excess of those of previous years.

In Table 47, the cases against The City have been grouped under the stations which it was claimed caused the damage, and the amount of damages claimed and amounts finally awarded are given. It will be seen that the greatest number of cases have been brought by land owners about the Spring Creek driven-well station, and by far the largest damages have been paid there. Spring Creek station is, however, surrounded by large areas of low land, lying just above the water-level in the sand, and these lands are devoted to truck farming. The City owns but a narrow strip of land at this point, and many of these small farms are not far from the wells of the station. The awards thus far made at Spring creek have amounted to $116,000, and cover a distance of 6500 feet along the conduit line. The probable additional awards to be made at this station in suits instituted but not yet disposed of, would increase the damages at Spring creek by $400, on the basis of the awards made to date, and to this must be added the cost to The City for defending the suits, which would average about $1,000 for each case, or $47,000. The cost per mile on this basis would, therefore, be $133,000. This represents, probably, the maximum cost per mile of works for damages, and is not a fair basis on which to estimate cost in other localities where the ground is higher relative to the water-table. Owners of property near driven-well stations on high ground have

TABLE 47

Actions Brought Against the City of Brooklyn, and The City of New York as Its Successor, for Damages Due to the Diversion of Water, Arranged by Stations

Station	Suits Brought		Suits in Which Awards Were Made			Suits Dismissed or Dropped		Suits Pending	
	Number	Amount Claimed	Number	Amount Claimed	Amount of Awards	Number	Amount Claimed	Number	Amount Claimed
New Lots	2	$14,300	2	$14,300	$2,020	..	......	..	......
Spring Creek	53	434,750	45	371,950	115,979	6	$61,500	2	$1,300
Baiseleys	5	81,500	5	81,500	26,080	..	......	..	......
Jameco	3	25,263	3	25,263	13,934	..	......	..	......
Springfield Forest Stream	15	109,920	4	34,500	5,127	3	19,320	8	56,100
Clear Stream	6	93,478	4	79,596	19,979	1	2,500	1	11,382
Watts Pond	4	35,300	2	13,300	1,750	..	......	2	22,000
Smiths Pond	1	6,250	1	6,250	26	..	......	..	......
Agawam	19	274,800	8	74,800	9,097	8	160,000	3	40,000
Merrick	1	25,000	..	......	......	..	......	1	25,000
Matowa	3	27,600	1	7,600	1,403	..	......	2	20,000
Wantagh	15	307,000	4	17,000	6,091	2	160,000	9	130,000
Massapequa	2	7,000	..	......	......	..	......	2	7,000
*Tidal Waters	4	65,900	..	......	......	4	65,900	..	......
Totals	**133**	**$1,508,061**	**79**	**$726,059**	**$201,486**	**24**	**$469,220**	**30**	**$312,782**

*These cases were brought by the town of Hempstead for diversion of water from tidal streams, and covered all streams on the watershed from Millburn east to Massapequa. Under an act of the Legislature, $50,000 was paid to the town to settle all past and future damages

not been able to prove any great amount of damage and the awards have consequently been small. The amount of damages thus far recovered has been 26 per cent. of the amounts claimed. The payments made for damages have usually included awards for both fee and rental depreciation of the property and new suits cannot, therefore, be brought on the same property.

To determine the average cost to The City for damages due to diversion of underground waters, the total amount of the awards already made, the cost of defending the suits, and the probable awards to be made in cases which are now pending, should be included. The total cost of the suits may be estimated as follows:

Awards made	$201,500
Town of Hempstead	50,000
Estimated awards in pending cases	80,000
Cost of defense in past and pending cases	100,000
Total	$431,500

This amount covers suits brought on account of 13 stations. The damages due to diversion of water may be estimated to cover 13 miles of watershed, and the cost per mile of watershed measured along the conduit line may be approximately estimated at $30,000. If the Spring Creek cases be eliminated, the cost per mile would be reduced to approximately only $25,000.

If the awards for damage amounted to even $50,000 per mile it would not be an extravagant charge on the works. This would correspond to a total cost of $650,000 for all suits and the interest and sinking fund charges estimated at five per cent. per annum would be $32,500. During the last two years an average supply of 70 million gallons per day of ground-water has been secured from the Ridgewood system, which would amount to 25,550 million gallons per year. The cost of damage suits for each million gallons of water supplied would be only $1.27, which is insignificant compared to the total present cost of the whole Ridgewood supply, which is estimated at $63 per million gallons delivered to the consumer.

The cost of the suits thus far instituted, $431,500, would make the charge per million gallons only $0.85.

In the cases against The City in Nassau and Queens counties, the plaintiffs have frequently made extravagant claims as to the depth of the lowering of the water-table. The City has been handicapped by the lack of continuous records of water-level in test-wells within the territory affected, and it has therefore been necessary to introduce testimony as to the probable normal water-level under the premises covered by the action, in order to show whether or not the water-level had been lowered, and if so, to what extent. Suits have been brought in cases where it was apparently impossible that any interference with the water-level could have been caused, by the operation of the driven-well stations, but in these cases the awards made, if any, have been small. In the majority of cases tried, The City has had to admit that the ground-water works had caused some lowering of the water-table, and therefore it became a technical trespasser and liable to action. The actual lowering in the majority of cases tried has been less than two feet.

Location of Cases

On Sheet 152, Acc. L 692, are shown the approximate locations of the property on which damage has been claimed in suits brought against The City. Note that these cases, almost without exception, are on low lands near the shore or in the valleys, and that there have been but few cases over a mile from the works.

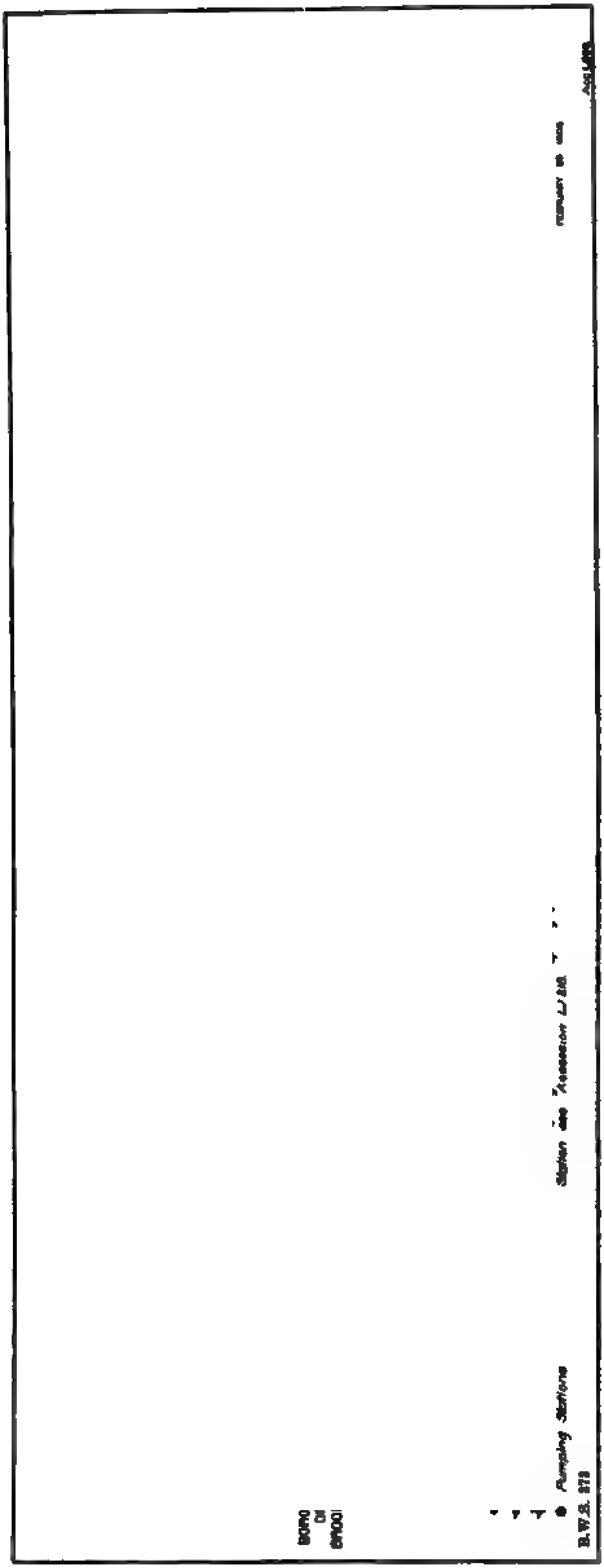
Since the early Spring Creek suits were the basis for the major portion of the damages recovered (see Forbell case), and over half the payments have been made to land owners near this station, Sheet 153, Acc. LJ 218, has been prepared to show the location of these Spring Creek cases, their relation to the wells of the Spring Creek pumping-station, and the amounts of damages claimed and the amounts awarded.

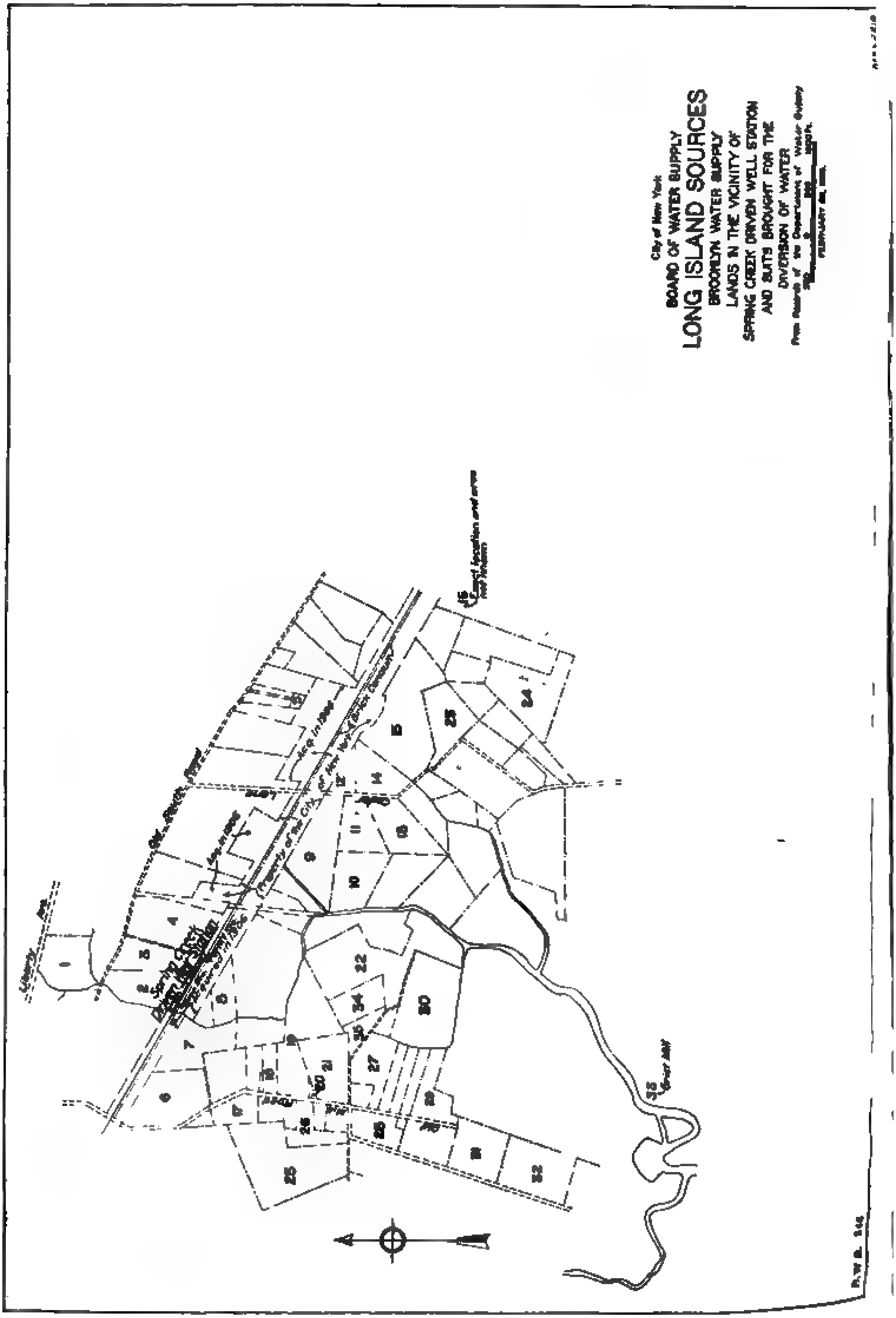
PROBABLE DAMAGES FROM DIVERSION OF SUFFOLK COUNTY GROUND-WATER

A most liberal estimate has been made in the cost of the Suffolk County works, to cover payments that might be made in the future to compensate the property owners there for any damage caused by the diversion of the ground-waters. With the experience gained in the operation of the Ridgewood system, it is proposed, however, to locate the Suffolk County

collecting works well back from the south shore on high ground within a wide right-of-way, where the lowering of the ground-water would cause but little or no damage or annoyance to the farmers and other residents.

Liberal damages would, of course, be paid, as in Nassau and Queens counties, where it was shown that damage had been done, but it is believed such claims would be small on the proposed Suffolk County works, and complete records of the elevation of the ground-water would easily disprove many claims when presented.


Pumping Stations


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
BROOKLYN WATER SUPPLY
LANDS IN THE VICINITY OF
SPRING CREEK DRIVEN WELL STATION
AND SUITS BROUGHT FOR THE
DIVERSION OF WATER
Spring Creek
Property of the City of New York
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2
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APPENDIX 17

REPORT ON PRELIMINARY SURVEYS, NOVEMBER, 1906 TO MAY, 1908

BABYLON, New York, June 16, 1908.

J. WALDO SMITH, ESQ.,
Chief Engineer, Board of Water Supply,
299 Broadway, New York City.

SIR:—I submit herewith a final report on the preliminary surveys for the proposed Suffolk County supply. Appended to this brief introduction are chapters on triangulation, levels and topographical surveys written by John L. Hildreth, Jr., Assistant Engineer, which, with the tables attached, represent a complete record of the survey work on Long Island from November, 1906, to May 1, 1908, when the preliminary stage of this work may be considered to have ended.

This does not include triangulation and topographical surveys in the Narrows, New York harbor, which were done under my direction for Headquarters department.

TRIANGULATION

SUFFOLK COUNTY

A system of quadrilaterals was established in the latter part of 1906 in southern Suffolk county from the Nassau-Suffolk county line to Quogue and Riverhead, covering a width of three to five miles, for the control of the surveys of the proposed aqueduct lines and the future topographical surveys of the watershed to protect The City in damage suits arising from the operation of the proposed ground-water works. This triangulation was the ground work for a system of rectilinear co-ordinates of which Prospect Park water-tower, Brooklyn, is the origin.

The triangulation work was done, for the most part, in the winter, when the weather conditions were seldom favorable for the most accurate work, and the observations were made on the standard transit, with a 5-inch circle, and a 20-second vernier. It required much zeal and endurance, during cold winter weather, tò work all day on a high tower with

one of these light instruments, and the accuracy of the results obtained is, therefore, most gratifying, and reflects great credit on the assistants who did this work. The closures between the three base lines, measured near Babylon, Holtsville, and Eastport, respectively, were remarkably good, and the comparisons with the positions given by the Coast Survey for several points along the south shore of Suffolk county included in our system, showed an agreement with the Coast Survey work of about 1 in 60,000. Probably our triangulation is safely within 1 in 20,000. About 160 square miles in Suffolk county were included in the primary system, and within this, secondary points were established, as noted in Appendix A. Thirty-one primary stations and 80 secondary stations were occupied.

The entire cost of the triangulation work in Suffolk county is estimated at $14,000, which amounts to about $87.50 per square mile of the entire area covered by the primary system.

Nassau and Queens Counties

No primary triangulation work was done in Nassau or Queens county. The position of the stations previously established by the topographical bureau of Queens, was referred to Prospect tower, the common origin of the Suffolk county surveys and the traverses in Queens tied in to these stations.

The survey of the aqueduct lines in Nassau county was controlled by the triangulation on either end, and by intermediate Coast Survey stations.

LEVELS

All the work thus far done is referred to a datum, 1.72 feet below that of the Brooklyn Water Department, in accordance with your instructions of May 16, 1907. This datum was assumed from existing information, to be co-incident with mean sea at Sandy Hook, the datum plane adopted by the Board of Water Supply for the Catskill aqueduct, but subsequent levels in the winter of 1907-1908 showed the assumed datum to be 0.39 foot below mean sea at Sandy Hook. It was found by previous levels that the datum plane adopted throughout Long Island by the U. S. Geological Survey, which is mean sea at Willett's Point, was 1.087 feet below the Brooklyn datum, and therefore 0.63 foot above the zero assumed for the

work of the Long Island department. The relative elevations of the several datum planes are summarized below.

Datum	Number of Feet of Zero of Given Datum Above Datum Plane Assumed by the Board of Water Supply in 1907 for Long Island Work
Board of Water Supply, mean sea at Sandy Hook	0.39
Brooklyn Water Department.........	1.72
U. S. Geological Survey, mean sea at Willetts point	0.63
Mean sea in the Great South bay as determined in 1907	0.8

Suffolk County Levels

In the winter of 1906-1907, Assistant Engineer Charles Goodman established primary bench-marks in Suffolk county from the Smith's Pond datum of the Brooklyn Water Department, which were later corrected by the 1.72 feet, to obtain an approximate mean sea datum as noted above. These primary bench-levels were made the subject of a special report by Assistant Engineer Goodman, dated February 16, 1907, and submitted to you from this office on May 3, 1907, which was afterward embodied in a later report by Headquarters department of February 18, 1908.

In accordance with the recommendations of the report of May 3, 1907, 15 bench-marks have been established in Suffolk county, where Assistant Engineer Goodman found no permanent points. These new benches have been levelled on and are shown in Appendix B of this report.

From these primary bench-marks, secondary levels were run throughout the southerly portion of Suffolk county, and over the entire island east of Port Jefferson and Patchogue as far as Riverhead. This work was done to determine the elevations of test-wells for ground-water observations and for the control of the topographical surveys. The closures of the

secondary levels were all within 0.03 for C in the formula $E = C \sqrt{M}$, in which E = error of closure in feet, M = length of run in miles.

Altogether, 899 miles of secondary levels were run at a total cost of $9,135 or $10.15 per mile. About half of this expense was incurred in the field; the remainder was spent in the office in working up notes and tabulating the results.

Nassau and Queens Counties

The survey lines for the proposed aqueduct through Nassau and Queens counties were near the lines of the primary levels and no work of importance was necessary to establish bench-marks for the topographical surveys between Brookiyn and the Suffolk County line.

TOPOGRAPHICAL SURVEYS

The level character of the outwash plains of southern Long Island afforded a wide choice of location for the proposed aqueduct and collecting works, and it was essential, on all promising lines, to cover a sufficient width of ground to allow of some adjustment of the paper location that was adopted for the preliminary estimates of cost. Special methods described in Appendix C, were devised by Assistant Engineer Hildreth to secure from a single traverse all the topography over a wide strip of land. Ordinarily, a width of 1000 feet was covered throughout Suffolk county and much of Nassau county. All traverses were closed within 1 in 6000.

During this work, 18,400 acres were surveyed, at a total cost of $42,215 which corresponds to $2.29 per acre, or about $1470 per square mile.

Mapping of Surveys

All this topographical work has been mapped on mounted white paper sheets 26 inches by 40 inches, on a scale of 200 feet to the inch. Each sheet is divided by the rectangular co-ordinate lines into six 12-inch squares, and completed in accordance with the standards fixed by the Engineering bureau. Altogether, 180 sheets have been laid out, and all surveys, with the exception of a few short traverses in northern Queens county have been plotted, checked and inked.

SUMMARY OF WORK

The total amount of work accomplished, and the estimated cost are summarized below:

	Amount of Work	Estimated Cost	
		Total	Unit Cost
Triangulation..............	160 square miles	$14,000	$87.50 per square mile
Levels, exclusive of Goodman's work previously reported..................	899 miles	9,135	10.15 per mile
Topographical surveys......	18,400 acres	42,215	2.29 per acre
Total cost of surveys, exclusive of primary levels.............	....	**$65,350**	

The tabulations of all this work as made up for field and office use, are given in the following pages and are submitted for filing at Headquarters department.

Respectfully submitted,

WALTER E. SPEAR,

Division Engineer

APPENDIX A

TRIANGULATION WORK IN SUFFOLK, NASSAU AND QUEENS COUNTIES

BY JOHN L. HILDRETH, JR., ASSISTANT ENGINEER

For the control of the topographical surveys in Suffolk county, a system of triangulation was established, in the latter part of 1906 and in 1907, from the Nassau-Suffolk County line to Riverhead and Quogue, a distance of about 40 miles. A system of quadrilaterals was laid out covering a width from three to five miles in southern Suffolk county, which included several U. S. Coast Survey stations previously established.

Prospect Park tower in Brooklyn, the origin of co-ordinates selected for the triangulation in Brooklyn and Queens boroughs (Latitude 40° 40′ 20.721″, Longitude 73° 58′ 03.841″), was taken as a zero of plane co-ordinates, or, more properly, linear spherical co-ordinates for the work in Suffolk county. From this station, plane co-ordinates of "Welwood," a triangulation station near Lindenhurst, were computed from the geographical positions of these two stations given by the Coast Survey. From the co-ordinates of "Welwood," the positions of all other stations in Suffolk county were determined by means of the triangulation work of the Board, and all checked by the geographical positions of other Coast Survey stations in Suffolk county that were included in our quadrilateral system.

Within this primary system, secondary triangulation stations were located about one mile apart, near the proposed aqueduct location, for convenience in running the stadia surveys.

Wherever possible, existing structures such as buildings, windmills, water-tanks, etc., were utilized for both primary and secondary stations, but it was found necessary to erect several towers in order to obtain good quadrilaterals in the primary system.

Three different styles of towers were used, all of which proved to be very satisfactory.

TRIANGULATION TOWERS

NAME	HIGHT FEET	KIND	BUILT BY	MATERIAL	REMARKS
Keith.........	50	4 post	Contract	Sawed lumber	
Yaphank......	40	4 "	Engineers	Oak and pine trees	
Raynor.......	38	4 "	"	" " " "	
Holtsville......	30	3 "	Contract	Sawed lumber	
Mastic........	40	3 "	Engineers	" "	
East base*....	18	4 "	"	Oak and pine trees	
Terry No. 2....	15	4 "	"	" " " "	Eccentric station of Terry

*Near Eastport

Plates 31 to 54, inclusive, show all the primary stations except "East" and "West" base in Lindenhurst, "East" and "West" base at Eastport, "Osborn" and "Terry."

In order to hasten the work, the system was divided into three divisions: Babylon, extending from Amityville to Islip; Patchogue, extending from Islip to Bellport; and Moriches, covering the remainder of the island east of Bellport. A separate base-line was laid out and measured on each division, and from it the work of each division calculated.

METHOD OF MEASURING BASE-LINES

BABYLON DIVISION

Location.....On south side of embankment of Hempstead branch of Long Island railroad north of Lindenhurst, between "West" and "East" base.

Length......6,349.653 feet.

Tape used...100-foot Eddy divided to 1/100 foot.

Supported...At 0, 25, 50, 75 and 100-foot points.

Pull.........20 pounds.

Method......Distance was measured between hubs 99+ feet apart, set on uniform grades; both ends of the tape were read, the 1/1000 foot being estimated. Tape shifted and the measurement repeated three or more times, allowable difference between maximum and minimum being 2/1000 foot. Temperature taken with each measurement at both ends of the tape. The sum of the averages of all the measurements being used for the total length.

Two measurements were made checking within 1/26500.

On account of the better conditions during the second measurement, this was used in calculating the quadrilaterals.

PATCHOGUE DIVISION

Location.....Along the Main Line division of Long Island railroad between hubs opposite "Holtsville" and "Ronkonkoma." Distance "Holtsville" to "Ronkonkoma" calculated from this.

Length......23,275.420 feet.

Tape used...100-foot Lufkin graduated to feet except the first foot, which was graduated to 1/10 foot.

Supported...On rail, except for 726.350 feet at one end. The latter being supported at 0 and 100-foot points by hubs.

Pull.........16 pounds.

Method......Tape stretched with required pull, rear end laid on rail, then front end lowered on rail keeping the pull constant, and the distance carefully marked with pencil. The remaining distance, 726.350 feet, was measured between hubs with an Eddy tape divided to 1/100 foot using the same pull.

Temperature taken at both ends of the tape with each measurement. Four measurements were made, but the third was eliminated on account of unfavorable conditions.

The average of these three measurements was used for calculating the quadrilaterals.

Error	between	1st	measure	and	mean	1/73200
"	"	2nd	"	"	"	1/86600
"	"	4th	"	"	"	1/478700

MORICHES DIVISION

Location.....Along Manor branch of Long Island railroad near Eastport between "West" and "East" base.

Length......10,259.105 feet.
Supported...At 0 and 100 feet.
Pull.........16 pounds.
Method......Base-line divided into 12 parts by hubs set from 300 to 1400 feet apart, the distance between hubs being measured two or more times, tape being held level, using plumb-bobs. Allowable difference being 2/1000 foot after correcting for temperature.
Temperature taken every 200 or 300 feet.

STANDARDIZING OF TAPES

In order to have all measurements agree with the U. S. Standard and to obtain checks on the work through the United Coast Survey stations, the tape used on the Babylon base was sent to Washington and standardized under the same conditions as when used. Afterward the tapes used on the Patchogue and Moriches bases were standardized with this tape over 700 feet of the Babylon base.

METHOD OF TURNING PRIMARY ANGLES

Division	Method of Measuring Angle	Number of Sets	Limit Error Between Sets Seconds	Total Number of Angles
Babylon	*Left to right angle and explement six times, telescope reversed between each angle	2	3	24
Patchogue	Left to right and right to left, six times, angle and explement. Telescope reversed between each angle. Plate set at zero	2	3	24
Moriches	Left to right, telescope direct for three and reversed for three. Set in different parts of plate	4	5	24

*Method used in the triangulation of City of New York by Mr. Mossman

For turning the angles in both primary and secondary work, an ordinary Buff and Buff or Berger & Son's engineer's transit, with 5-inch plate, reading to 20 seconds was used. Signal poles, varying from two to six inches in width depending on the length of sight, and painted with alternate bands

of black and white, with a flag at the top, or the center of the windmills or spires, were used for sights.

Six to seven miles were about the limit of sight, under good conditions, of these instruments.

A triangulation party consisted of an instrument man (assistant engineer usually) and recorder, and two or more assistants to raise and lower signals whenever necessary. From one to two primary angles, two to four secondary angles, and angles to azimuth stakes, under ordinary conditions, could be turned in a day.

Weather conditions and the low power of the instruments were responsible for the apparently small amount of work done.

CALCULATION OF TRIANGULATION

After correcting such angles as were measured from eccentric stations, the quadrilaterals were adjusted by the angle and side equation adjustment, the rigorous method not being used. The base-line was first corrected for temperature to 62° F., then to U. S. standard, and finally reduced to the horizontal. This was then reduced to sea-level and used to calculate the quadrilaterals. In each case, the easterly side of the quadrilaterals was calculated through the north and south sides and the average used to go ahead with. In one case two quadrilaterals, " Vulcanite " and " Babylon " had two sides in common which were calculated from both with the following results:

Side	Calculated from Quadrilateral	Length Feet	Difference Feet
St. Dominic to Belmont.....	Vulcanite..............	18,613.047	
" " " "	Babylon...............	18,612.395	0.652
Belmont to Sherman........	Vulcanite..............	13,034.360	
" " "	Babylon...............	13,034.010	0.350

The table following gives the closures of the angles of the quadrilaterals, the error per angle, maximum, minimum and average correction per angle:

CLOSURES OF QUADRILATERALS

Quadrilateral	Sum of Observed Angles			Total Error in Seconds	Error per Angle in Seconds	Correction in Seconds		
	Degrees	Minutes	Seconds			Maximum	Minimum	Average
Amityville	359	59	48.6	−11.4	−1.42	6.2	0.2	2.79
Base	359	59	57.2	− 2.8	−0.35	3.2	0.7	1.88
Vulcanite	359	59	57.9	− 2.1	−0.26	1.9	0.0	0.94
Babylon	359	59	53.7	− 6.3	−0.79	3.1	0.8	1.54
Bayshore	360	00	06.0	+ 6.0	+0.77	5.5	0.5	2.23
Islip	360	00	08.7	+ 8.7	+1.09	2.2	0.1	1.11
Patchogue	359	59	55.9	− 4.1	−0.51	2.7	0.0	1.13
Oakdale	359	59	51.3	− 8.7	−1.09	6.6	1.8	3.71
Cutting	359	59	57.7	− 2.3	−0.29	4.4	0.8	2.02
Bellport	360	00	05.7	+ 5.7	+0.71	3.4	0.1	1.61
Brookhaven	359	59	49.8	−10.2	−1.27	3.0	0.4	1.50
Mastic	359	59	57.8	− 2.2	−0.28	1.8	0.4	1.05
Moriches	360	00	05.3	+ 5.3	+0.66	4.3	0.5	1.65
Eastport	360	00	07.7	+ 7.7	+0.96	1.9	0.0	1.04
Westhampton	359	59	56.1	− 3.9	−0.49	3.0	0.3	1.16
Base	359	59	57.8	− 2.2	−0.28	1.7	0.2	0.80

Average correction per angle 1.63 seconds

Closures Between the Different Divisions

BABYLON AND PATCHOGUE

Division	Line between Islip and Central Islip
Babylon	19,127.293 feet
Patchogue	19,127.289 "
Difference	0.004 foot

PATCHOGUE AND MORICHES

Division	Line between Plainfield and Bellport
Patchogue	23,861.563 feet
Moriches	23,861.336 "
Difference	0.227 foot

As the work between the three divisions closed so well, and as "Welwood" was a U. S. Coast Survey station whose

co-ordinates and that of Fire Island lighthouse, and the azimuth of the line between them had been furnished through the courtesy of the United States Coast Survey, it was decided to hold the work of the Babylon division and adjust the other quadrilaterals to it, which was accordingly done.

The following closures in co-ordinates and in azimuth were obtained on the U. S. Coast Survey stations, either occupied or cut in:

Station	Co-ordinates		Calculated From	Difference in Feet	
	North	East		North	East
Babylon Presbyterian church.	9,594.551	178,869.953	Fire Island light...........	0.175	0.237
	9,594.376	178,870.190	Welwood		
	9,594.464	178,870.072	Average		
	9,594.405	178,869.223	Triangulation............. St. Dominic–Belmont	0.059	0.849
	9,594.402	178,869.101	Triangulation............. Sherman–Belmont	0.062	0.971
Patchogue school.......	34,355.38	264,327.84	Welwood		
	34,355.83	264,327.41	Fire Island light...........	0.45	0.43
	34,355.61	264,327.63	Average		
	34,359.76	264,323.65	Triangulation.............	4.15	3.98
Bellport church.	33,634.48	285,688.74	Patchogue school		
	33,635.59	285,690.03	Triangulation............. Patchogue school–Holtsville	1.11	1.29
Osborn........	78,205.18	347,621.08	Welwood		
	78,207.44	347,619.30	Fire Island light...........	2.26	1.78
	78,206.31	347,620.19	Average		
	78,207.74	347,617.07	Triangulation.............	1.43	3.12
Terry.........	67,520.48	331,946.8	Welwood		
	67,552.76	331,945.3	Fire Island light...........	2.28	1.5
	67,521.62	331,946.05	Average		
	67,523.78	331,944.74	Triangulation.............	2.16	1.31

Station	Co-ordinates		Calculated From	Difference in Feet	
	South	East		North	East
Fire Island....	13,675.50	207,828.66	U. S. Coast Survey		
	13,673.22	207,827.20	Triangulation............. Sherman–Belmont	2.28	1.46
	13,672.30	207,825.23	Triangulation............. Holtsville–Patchogue	3.20	3.43

Line	Azimuth			Calculated from	Difference in Seconds
	Degrees	Minutes	Seconds		
Patchogue school to Fire Island light...	229	37	52.2	Geographic co-ordinates	
	229	37	49.8	Triangulation.........	2.4
Terry to Osborn.....	55	42	36.4	Geographic co-ordinates	
	55	43	02.1	Triangulation.........	25.7
Terry to Moriches Presbyterian church	216	59	35.2	Geographic co-ordinates	
	216	59	02.0	Triangulation.........	33.2

SECONDARY TRIANGULATION

These stations were selected at points approximately one mile apart, and as closely as could be determined at that time to where the aqueduct line would be located. In most cases, existing structures such as dwelling houses and small windmills were used, though in several instances it was necessary to erect signal poles 40 to 60 feet high or put flags in high trees and cut these in.

The method of turning angles was the same as on the primary work, except that only one-half the number of sets were turned. In all cases where it was possible the station was occupied, and the error of closure was proportioned equally among all three angles. Most of this work was done at the same time that the primary angles were turned, to avoid occupying a station twice. As these stations were calculated from only two primary stations, the only check on their accuracy was the closures of the traverses run in the field.

Azimuth Stakes

At all primary and secondary stations, except where the latter were simply poles or flags that were cut in, two or three azimuth stakes were set for closures of the traverses without the necessity of re-occupying the station again. These were used for closures both in azimuth and in co-ordinates. At all the primary and some secondary triangulation stations, these stakes have been replaced by concrete monuments.

Summary

Area, square miles	160
Primary stations	31
Secondary stations	80
Towers erected	7
Signals erected	77
Angles turned	657
Total length of base-lines	39,884.178 feet

TRIANGULATION

Salaries (surveys and calculations), materials, etc., except towers (No Executive)	$13,081.38
TOWERS	
"Keith," 50 feet	218.00
"East base," Eastport, 18 feet	29.00
"Terry," 15 feet	32.00
"Raynor," 38 feet	152.00
"Yaphank," 40 feet	150.00
"Mastic," 40 feet	207.00
"Holtsville," 30 feet	135.00
Total cost	$14,004.38
Cost per square mile	$87.50

TRIANGULATION WORK IN NASSAU COUNTY

For the control of the survey work through Nassau county from Amityville to Valley Stream, it was decided not to do any field work, but to utilize the U. S. Coast Survey stations on account of their proximity to the line. Five stations, "Episcopal spire" at South Oyster bay (Massapequa), "Fry's cupola" at Bellmore, "Presbyterian Church spire" at Freeport, "Methodist Church spire" at Baldwin, and "Pearsall's Methodist Church spire" at Lynbrook were used. Owing to the very poor closures obtained on all these stations except the first at Massapequa, they were abandoned and the work closed from station "Hospital" at Amityville to "Roeckels" at Rosedale, a distance of about 15 miles. In order to hasten this work, an additional party was started at Freeport and later at Lynbrook. At both of these places, an observation was made on Polaris, and from this an azimuth obtained to start the work.

TRIANGULATION WORK IN QUEENS COUNTY

For the control of the survey work in the County of Queens, extending from the Ridgewood reservoir to the Nas-

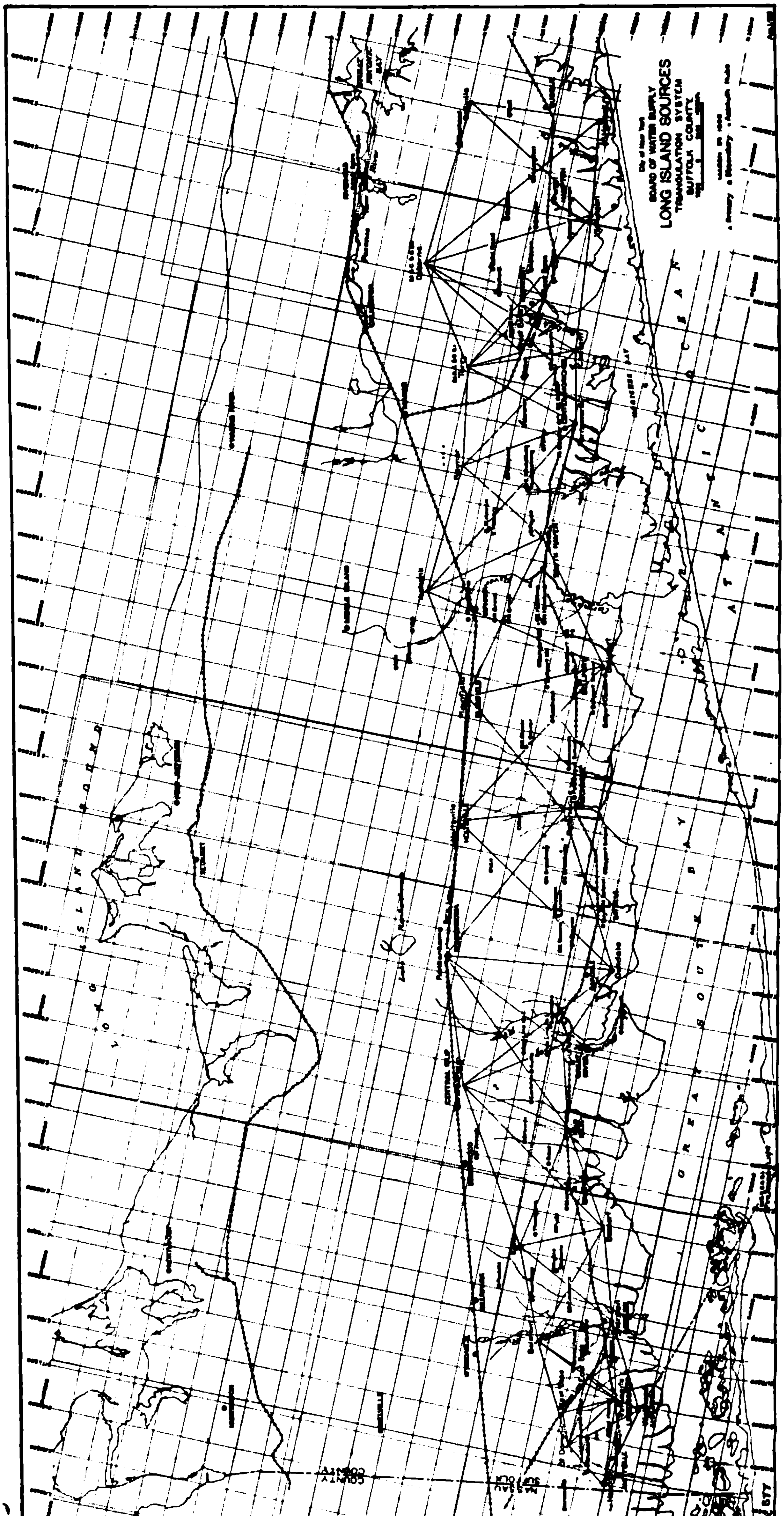
sau County line near Rosedale, a distance of about nine miles, four triangulation stations established by the Borough of Queens, "Ridgewood gate-house," "Aqueduct," "Metropolitan" and "Roeckels" were used. The co-ordinates of these stations in the old Bronx system, whose origin was on Eleventh avenue, were obtained from the topographical bureau of the Borough of Queens. In order to utilize these stations, it was necessary to obtain their co-ordinates in the system used on the remainder of the work, whose origin was Prospect Park water-tower in Brooklyn. This was done by first calculating their geographic position by transposing from the old Bronx system to the new with the Parkway origin, and thence to the Brooklyn system with Prospect Park water-tower (Latitude 40° 40′ 20.721″, Longitude 73° 58′ 03.841″) as a zero. The plane co-ordinates of these stations were then calculated. Azimuth stakes were set at all four stations, only such triangulation work being done to properly obtain their azimuth. For most of this work, "Hollis," a U. S. Coast Survey station, was used, as the stations were not intervisible. These four points were used for the stadia traverses along the aqueduct location.

For the surveys of a proposed reservoir site near Lake Success, in the Northern part of Queens borough, only one previously established station, "Hollis," was available. "Payne," where a tower had just been erected and was being occupied at the time of the surveys, was used to close on, its position being determined by the traverse.

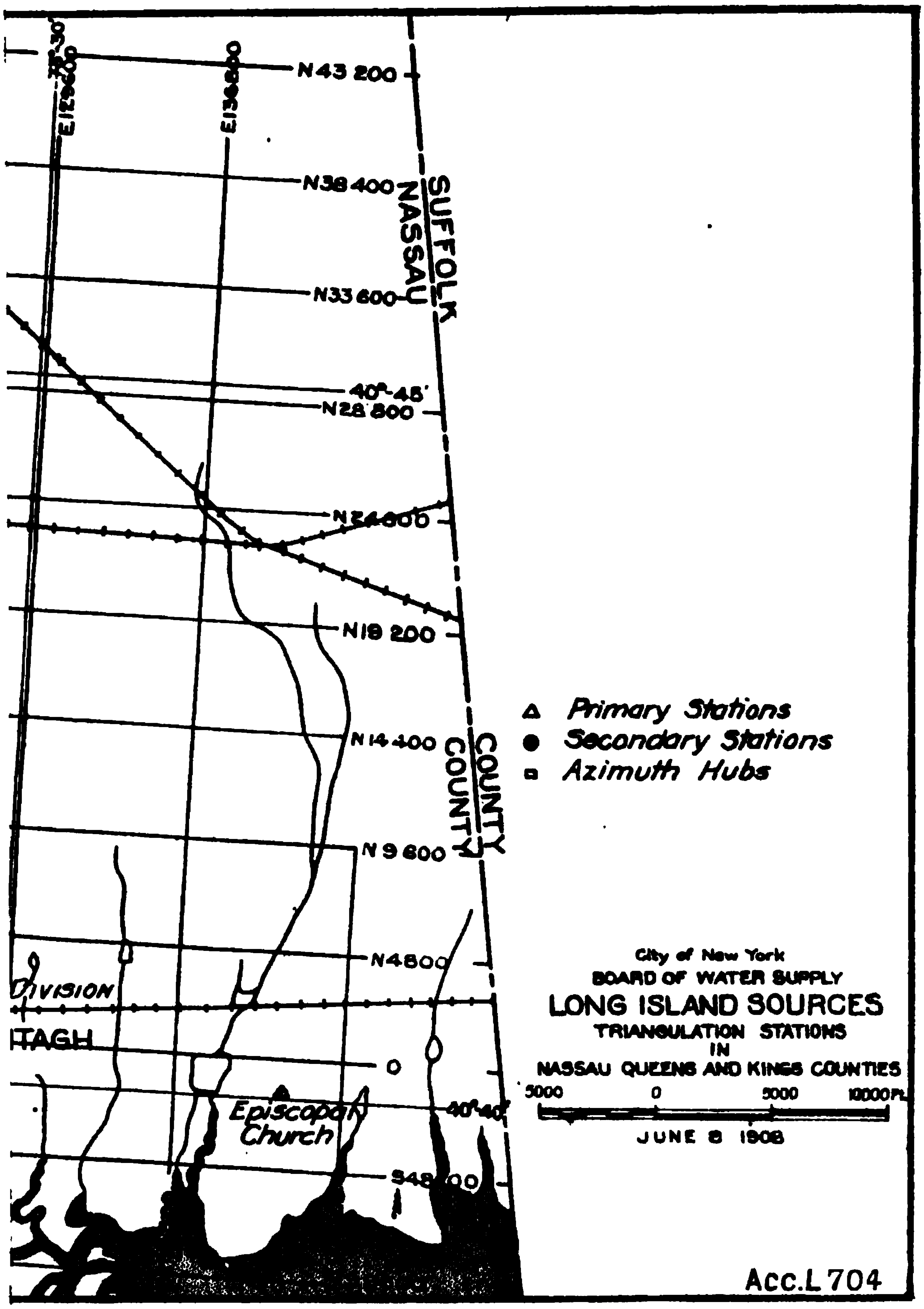
In turning the angles for the azimuth stakes, a 5-inch 20-second Buff and Buff transit was used. These were turned from left to right with reversals between each angle, six angles constituting a set. Four sets were usually turned to determine the angle. On part of this work, the explement of the angle was measured in the same manner and the average of the two taken for the true value. In the other cases, an additional angle was turned to another triangulation station, and the average of these two angles used. No towers or signals were erected on this work.

Ten stations were occupied and about 30 angles measured, at a total cost of about $300.

SHEET 154



BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
TRIANGULATION SYSTEM
SUFFOLK COUNTY
NASSAU COUNTY
SUFFOLK COUNTY
B.W.S. 577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N38 400
N33 600
40°-45'
N28 800
N24 000
N19 200
N14 400
N9 600
N4800
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40°-40'
S4800
SUFFOLK COUNTY
NASSAU COUNTY
DIVISION
Episcopal Church
Primary Stations
Secondary Stations
Azimuth Hubs
City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
TRIANGULATION STATIONS
IN
NASSAU QUEENS AND KINGS COUNTIES
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JUNE 8 1908
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TABLE 48

Primary Triangulation Stations

Station	Location Town	Structure	Hight of Instrument Above Ground	Description of Station
Hospital........	Amityville....	Tower of Long Island Home.	About 80 feet	Signal in east window at top of central tower of Administration building of the Long Island Home, on the north side of Division avenue; building painted brown
St. Dominic.....	Amityville....	Water tank...	65 feet	Signal pole on top of gray water-tank, 60 feet high, at St. Dominic's convent, on east side of Albany avenue, about 1½ miles northeast of Amityville
West Base......	Lindenhurst..	None........	5 feet	Signal on south side of embankment of Hempstead branch of Long Island railroad, about 130 feet northwest of road from Lindenhurst (straight path) to Wyandanch, marked by concrete monument
Welwood.......	Lindenhurst..	Dwelling house	50 feet	Finial on center of cupola of gray house of F. D. Neville, at northwest corner of Broadway and South Country road (Main street), Lindenhurst, U. S. Coast Survey station
Vulcanite.......	Lindenhurst...	Water-tank...	75 feet	Eccentric station on roof of large water-tank, 70 feet high, of Vulcanite Mfg. Co., on east side of Dougherty avenue, and south of Long Island railroad
East Base.......	Lindenhurst..	None........	5 feet	Signal on south side of embankment of Hempstead branch of Long Island railroad, about 400 feet southeast of Cemetery road, marked by concrete monument
Belmont........	Babylon......	Windmill.....	80 feet	Signal on platform of large yellow windmill of August Belmont, south of Belmont avenue and about two miles northwest of Babylon
Sherman........	Babylon......	Cupola of hotel	65 feet	Eccentric signal on roof of cupola of Sherman House on south side of Main street, opposite Deer Park avenue, in Babylon village
Keith.	Bayshore.....	Tower.......	50 feet	50-foot 4-post triangulation tower, on east side of road from Edgewood to Bayshore, about one mile south of Edgewood, on land of M. C. Keith. Concrete monument under tower
Bossert.........	Bayshore.....	Water-tank...	78 feet	Signal on center of roof of water-tank, 73 feet high, on land of Louis Bossert on north side of South Country road about one mile west of Bayshore
Islip...........	Islip.........	Coal elevator..	47 feet	Signal on top of coal elevator of Islip Coal & Feed Co., south of railroad and west of Nassau avenue
Central Islip....	Central Islip..	Roman Catholic church...	50 feet	Gilt cross on spire of church, on east side of Carleton avenue, about 2,000 feet south of railroad
Cutting.........	Islip.........	Windmill.....	50 feet	Center of gray windmill on land of W. B. Cutting, north of Montauk division of Long Island railroad, and about ½ mile east of Great River railroad station
Ronkonkoma....	Islip.........	Dwelling house (empty)	35 feet	Center of cupola of empty dwelling house on Ocean avenue, north of main line of Long Island railroad and about one mile west of Ronkonkoma railroad station
Oakdale........	Islip.........	Windmill.....	75 feet	Center of gray windmill south of South Country road and about one mile east of Oakdale railroad station, on land of F. C. Bourne's Indian Neck farm

TABLE 48 (*Concluded*)

Station	Location Town	Structure	Hight of Instrument Above Ground	Description of Station
Holtsville	Brookhaven	Tower	30 feet	30-foot 3-post triangulation tower on land of Long Island railroad, 800 feet east of Holtsville railroad station. Concrete monument under tower
Patchogue	Brookhaven	Water-tank	92 feet	Center of water-tank of Patchogue Mfg. Co., about 300 feet north of South Country road and near Lace Mill pond. Concrete monument under tower
Plainfield	Brookhaven	Water-tank	53 feet	Center of yellow water-tank of Long Island railroad, four miles north of Bellport at No. 2 experimental agricultural station
Bellport	Brookhaven	Windmill	44 feet	Center of windmill on John L. Langley's estate, ½ mile east of Bellport, on south side of South Country road
Yaphank	Brookhaven	Tower	38 feet	37-foot 4-post triangulation tower, built of oak and pine trees, on land of Young and Metzner, 1½ miles north, and ½ mile east of Yaphank railroad station
Mastic	Brookhaven	Tower	40 feet	40-foot 3-post triangulation tower on estate of Christopher Roberts (R. M. Galloway), 300 feet south of South Country road, opposite house of Wm. Bremmohl, and one mile west of Mastic railroad station. Concrete monument under tower
Raynor	Brookhaven	Tower	40 feet	40-foot 4-post triangulation tower, built of oak and pine trees on Prospect Hill, South Manor, on land of E. E. Raynor, and ¼ mile south of his house. Concrete monument under tower
Farnsworth	Brookhaven	Windmill	57 feet	Center of white windmill on barn of A. B. Farnsworth, on east side of Ocean avenue in Center Moriches, one block south of Center Moriches Roman Catholic church
Terry	Brookhaven	None	5 feet	U. S. Coast Survey station. Tile drain pipe filled with concrete on highest point of Rock hill, on land of Mrs. Allen, ¼ mile south of and 1½ miles east of South Manor Presbyterian church
West Base	Brookhaven	None	5 feet	On Long Island Railroad right-of-way, Manor branch, 30 feet south of track and about 5,200 feet west of Eastport railroad station, marked by concrete monument
East Base	Southampton	Tower	18 feet	18-foot tower over concrete monument, 30 feet north of railroad track, on right-of-way of Montauk division of Long Island railroad, and about 450 feet east of intersection of South Country road and railroad, half way between Eastport and Speonk
Convent	Brookhaven	Water-tank	52 feet	Center of largest water-tank (white) at Roman Catholic convent, in Center Moriches, ½ mile south and one mile east of East Moriches railroad station
Osborn	Southampton	None	5 feet	U. S. Coast Survey station. Tile drain pipe filled with concrete on Bald hill, 2¾ miles south and 2¾ miles west of Riverhead
Oakville	Southampton	None	5 feet	Hub on northwest knob of hill on land of Flanders club, 1½ miles northeast of Oakville, near lookout tower of A. S. Post
Hallock	Southampton	Windmill	80 feet	Center of white windmill on land of A. B. Hallock at intersection of Main street and Beach road, in Quogue

TABLE 49

Secondary Triangulation Stations

Station	Location	Structure	Description of Station
Slender	Amityville	Windmill	Signal on steel windmill 30 feet high, near east side of Broadway, about ½ mile north of Amityville
Monahan	Amityville	Dwelling house	Center of cupola on house of John Monahan, on south side of Harrison avenue, about midway between Broadway and Albany avenue
Copiague	Copiague	Signal pole	Two by two hub, about 70 feet south of Dixon avenue and about half way between Great Neck road and Bay View avenue
Red House	Lindenhurst	Red brick house	Center of cupola of red brick house belonging to Charles Bassler, about ¾ mile west of Lindenhurst
Lindenhurst	Lindenhurst	Signal pole	Two by two hub on west side of Welwood avenue about 1,000 feet south of Straight path (road to Wyandanch)
Green House	West Babylon	Dwelling house	Center of cupola of 2-story green house (frame) belonging to W. P. Ketcham, near Farmingdale road
Anderson	West Babylon	Water-tank	Signal on top of water-tank near house of C. F. Anderson, on west side of Great Neck road, about ¼ mile south of railroad
Blatchford	West Babylon	Dwelling house	Signal on top of roof of 2-story white frame house of Andrew Blatchford, on east side of road from intersection of Belmont avenue and Si. Udall road, to Little East Neck road
Cockerill	Babylon	Windmill	Center of windmill (painted brown) on east side of Deer Park avenue opposite Si. Udall road, on land of John F. Cockerill
Houseman	North Babylon	Windmill tower	Center of disused windmill tower, on land of A. A. Houseman, about 200 feet east of east side of Deer Park avenue
Paddle	North Babylon	Windmill	Not located or marked
Sammis	West Islip	Signal pole	Two by two hub on west side of Udall road, about 100 feet north of Muncy's road (Hunters avenue)
Higbie	West Islip	Signal pole	Two by two hub on east side of Udall road, about 550 feet north of Muncy's road (Hunters avenue)
Horn	West Islip	Signal pole	Two by two hub about 200 feet north of Long Island railroad, opposite siding Keith
Thompson	West Islip	Signal pole in tree	Not located or marked
Hyde	Bayshore	Signal pole in tree	Two by two hub near tall pine on land of Louis Bossert, about 500 feet south of Muncy's road, on second private road east of Manor lane
Electric	Bayshore	Chimney of water company	Center of chimney of Great South Bay Water Co., between Fifth and Clinton avenues
St. Joseph	Brentwood	St. Joseph's convent	Center of chimney at St. Joseph's convent
Race	Bayshore	Water-tank	Signal on water-tank of Bayshore Horse Show Association, north of Islip boulevard and about 600 feet east of Awixa avenue (Brentwood road)
Orowoc	Islip	Signal pole	Two by two hub in 38th street, about 150 feet east of Commack road, north of Brookville, on land of W. H. Moffitt
Fire Line No. 1	Great River	Signal pole	Concrete monument set 8 inches under ground about one mile north of Great River railroad station, on Fire Line
Fire Line No. 2	Great River	Signal pole	Not marked. Monument set at 24-L instead
24-L	Great River		Concrete monument about ½ mile north of Great River railroad station, and 700 feet north of Fire Line No. 1, set 8 inches below ground, on the Fire Line
Carleton	East Islip	Flag in tree	2½ by 2½ hub near high pine tree, 1,000 feet west of Carleton avenue and about one mile north of railroad

TABLE 49 (*Continued*)

Station	Location	Structure	Description of Station
Cutts	Great River	Signal on tree	2½ by 2½ hub near 12-inch pine, about 1,000 feet west of first trail or road east of Great River station, running north from South Country road, and ¾ mile north of railroad
Southside	Great River	Steel tower	Center of steel observation tower on Southside Sportsman's Club grounds
Connetquot	Great River	Windmill	Pump rod of windmill
North Bourne	Oakdale	Flag in tree	Flag in pine tree at intersection of Smithtown road and road running north to Bohemia; not cut down
South Bourne	Oakdale	Signal pole	2½ by 2½ hub on west side Smithtown road, about one mile north of railroad
*South Duncan	Sayville	Flag on tree	2½ by 2½ hub about 150 feet east of Moscow avenue and one mile north of intersection of Moscow and Carleton avenues
Sayville school	Sayville	School	Centre of cupola on yellow schoolhouse, on west side Green street, running south from west end of Long Island railroad station at Sayville
*North Duncan	Sayville	Flag on tree	2½ by 2½ hub 1,000 feet east of Moscow avenue and one mile north of intersection of Moscow and Carleton avenues
Mill	Holbrook	Windmill	Centre of pump-rod on windmill on Broadway avenue, three miles north of the South Country road
*North Broadway	Bayport	Windmill	Centre of pump-rod of windmill at intersection of Broadway avenue with Wheeler road
*South Broadway	Bayport	Signal on tree	2½ by 2½ hub about 200 feet east of Broadway avenue and ½ mile north of railroad
Bayport school	Bayport	School	Centre of cupola on yellow schoolhouse on west side Snedecor avenue, about ¼ mile south of railroad
Mott	Patchogue	Flag on tree	Nail in root of tree near house belonging to a Mr. Mott
Patchogue school	Patchogue	Schoolhouse	Centre of cupola on school on east side of Ocean avenue just north of Long Island railroad. This is a U. S. Government secondary
Summers	Patchogue	Windmill	Centre of pump-rod on square, boxed-in, white windmill on land of Admiral Summer
South Glover	East Patchogue	Signal pole	2½ by 2½ hub about 250 feet north of Barton avenue and 200 feet west of Robinson's road
North Glover	East Patchogue	Flag on tree	Located north, 1,050 feet of Barton avenue and 100 feet west of Robinson's road; not cut down
*Robinson	Hagerman	Signal pole	2½ by 2½ hub on road from East Patchogue to Yaphank, about one mile west from Dunton avenue
Hill	Yaphank	Signal in tree	Located at summit of hill on south edge of clearing, about 200 feet east of second wood road, running north, about one mile east of Coram hill; south of Judge Bartlett's farm
Hank	Yaphank	Signal pole	2½ by 2½ hub under giant pine in woods, 100 feet northwest of intersection of Grovey road and wood road running north and south, about 1½ miles east of Coram hill
Bellport—M. 1	Bellport	Signal pole	2½ by 2½ hub, one mile north of railroad and about 1,000 feet west of Bellport avenue
Bellport—M. 3	Bellport	Signal pole	2½ by 2½ hub, 1,200 feet north of railroad and 1,500 feet east of Bellport avenue
Bellport—M. 2	Bellport	Signal pole	2½ by 2½ hub, 1.2 miles north of railroad and 0.6 mile east of Bellport avenue
Bellport church	Bellport	Church spire	Centre of spire of white Presbyterian church, on the north side of South Country road, nearly opposite Rector avenue, Bellport
Yap	Yaphank	Signal in tree	Signal in tree on summit of highest hill on Vanderbilt estate, on east side of Carman's river and about one mile northwest of Yaphank post-office

TABLE 49 (*Continued*)

Station	Location	Structure	Description of Station
Poor farm.......	Yaphank.......	Water-tank.....	Centre of vane on water-tank of County poor farm, about ¼ mile northwest of Yaphank railroad station
North Brook....	Yaphank.......	Signal pole......	Located 600 feet west of Brookhaven road, about 0.7 mile south of Yaphank poor house. Not marked by hub, but by azimuth stakes near South brook
South Brook....	Yaphank.......	Signal pole.....	Located 500 feet west of Brookhaven road, about 1.2 miles south of Yaphank poor house, on land of F. Terwillinger. Not marked by hub, but by azimuth stakes on line to North brook
West Hawkins...	Brookhaven.....	Signal pole......	Located 500 feet east and about 700 feet north of junction of South Country road and Brookhaven to Yaphank road. Not marked by hub, but by azimuth stakes on line to East Hawkins
East Hawkins...	Brookhaven.....	Signal pole......	Located 900 feet east and about 2,000 feet north of junction of South Country road and Brookhaven to Yaphank road, on east side of cleared field on land of Miss Emma Hawkins. Not marked by hub, but by azimuth stakes on line to West Hawkins
West Haven.....	Payneville......	Signal pole......	Two by two hub, 1½ miles east of Carman's river, and 1.8 miles north of South Country road. Point is 600 feet east of wood road
East Haven.....	Payneville......	Signal pole......	Located 1½ miles east of Carman's river and 1.7 miles north of South Country road. Point is 1,000 feet east of wood road. Not marked by hub, but by azimuth stakes on line to West Haven
Payne..........	Payneville......	Signal pole......	Located 1½ miles east of Carman's river and 0.4 mile north of South Country road. Not marked by hub, but by azimuth stakes on line to Mastic
West Wheatling.	Moriches.......	Signal pole.....	Located 40 feet west of Forge River road, between Twin lakes, about ½ mile north of South Country road, on land of R. L. Davidson. Not marked by hub, but by azimuth stakes on line to East Wheatling
East Wheatling..	Moriches.......	Signal pole......	Located 600 feet northeast of Forge River road, between Twin lakes, about ½ mile north of South Country road, on land of Henry Walterling. Not marked by hub, but by azimuth stakes on line to West Wheatling
Prospect........	Moriches.......	Signal pole......	Located 300 feet south of road between Twin lakes, 0.7 mile north and 0.7 mile northeast of South Country road. Marked by azimuth stakes
Forge..........	Center Moriches.	Signal pole.....	Located on land of W. F. Smith, ½ mile north of South Country road. Not marked by hub, but by azimuth stakes on line to Terry No. 2
Marcher........	Center Moriches.	Signal pole......	Located on land of C. A. Marcher, 0.9 mile north of Center Moriches railroad station and 1,200 feet west of road. Not marked by hub, but by azimuth stakes on line to Terry No. 2
West Center....	Center Moriches.	Signal pole......	Located on railroad right-of-way, 30 feet south of track and 30 feet east of express house. Not marked by hub, but by monument on line to East Center
East Center.....	Center Moriches.	Signal pole.....	Located on railroad right-of-way, 40 feet north of track and 2,530 feet east of express house. Not marked by hub, but by monument on line to West Center
Reeve..........	East Moriches...	Windmill.......	Center of brown windmill tower on land of H. M. Reeve, one mile north of East Moriches railroad station
Roman Catholic church........	East Moriches...	Roman Catholic church.......	Center of light grey spire of Roman Catholic church, on the east side of the South Country road, 2,000 feet east of East Moriches railroad station and 1,000 feet north of railroad

TABLE 49 (*Concluded*)

Station	Location	Structure	Description of Station
Steinker........	Eastport.......	Water-tank tower	Center of white tower carrying water-tank on land of Charles Steinker on Manor road, ½ mile northwest of Bayside Inn and ¾ mile northwest of Eastport railroad station
Seatuck.........	Eastport.......	Signal pole.....	Two by two hub, 150 feet west of wood road, ½ mile west of Long Island Country Club and $\frac{1}{10}$ mile north of North Country road
Bald road.......	Eastport.......	Signal pole......	Nail in root of tree 500 feet west of first wood road west of East Branch creek and 1¼ miles north of North Country road
Fordham.......	Speonk.........	Windmill.......	Center of brown windmill on land of W. H. Fordham, 600 feet south of Speonk railroad station
Remson........	Speonk.........	Signal pole.....	Located 1,500 feet east of East Branch creek and 1,000 feet north of North Country road. Not marked by hub, but by azimuth stakes on line to Terry No. 2
Westhampton church.......	Westhampton...	Church.........	Center of tower on southeast corner of Methodist church on the north side of Main street, midway between Speonk river and Beaverdam creek
East Spire......	Riverhead......	Church.........	Center of east spire of Polish church, on the north side of Cemetery avenue, about 1,500 feet west of fair grounds
Beaver.........	Westhampton...	Signal pole......	Located 150 feet west and ½ mile north of intersection of railroad and South Country road. Not marked by hub, but by azimuth stakes on line to Osborn
Deacon.........	Westhampton...	Signal pole......	Located 400 feet east and 1½ miles north of intersection of railroad and South Country road. Not marked by hub, but by azimuth stakes on line to Osborn
Court House....	Riverhead......	Court-house....	Center of cupola of court-house on the west side of Griffin avenue near Riverhead railroad station
Tower mill......	Riverhead......	Tower of grist-mill..........	Center of tower on northeast corner of F. L. Griffin's grist-mill, on the west side of Peconic avenue and north side of Peconic river
Hampton.......	Westhampton...	Signal pole......	Two by two hub, 200 feet west of second road east of Westhampton railroad station, and 3,000 feet north of railroad
West Head......	Oakville........	Signal pole......	Two by two hub on north side of hill, 100 feet west of bicycle path from Quogue to Riverhead and N. Y. & N. J. telephone line and 3.1 miles south of Peconic river
Oak............	Oakville........	Signal pole......	One by three pine hub on stadia line, 1½ miles north of Quogue railroad station and 300 feet west of Quogue to Riverhead road. Station 619 AA on traverse line

*Hubs have been replaced by concrete monuments

PLATE 31

Station "Hospital" Long Island Home at Amityville.

Station "Wellwood" at Lindenhurst.

PLATE 34.

Station "Vulcanite" (water-tank) at Lindenhurst.

PLATE 35

Station "Belmont" (windmill) at North Babylon.

PLATE 36

Station "Sherman" at Babylon.

PLATE 37

Station "Keith" at Bayshore.

PLATE 33

Station "Bossert" (water-tank) at Bayshore.

PLATE 39

Station "Islip" (coal elevator) at Islip.

PLATE 40

Station "Central Islip" (Catholic Church spire) at Central Islip.

PLATE 41

Station "Cutting" (windmill) at Great River.

PLATE 42

"Ronkonkoma" at Ronkonkoma.

PLATE 43

Station "Oakdale" (windmill) at Oakdale

PLATE 44

Station "Holtsville" (tower) at Holtsville.

Station "Patchogue" (tower) at Patchogue.

PLATE 46

(lower) at Plainfield.

PLATE 47

Station "Bellport" (windmill) at Bellport

PLATE 48

Station "Yaphank" at Yaphank.

PLATE 49

Station "Mastic" near Mastic railroad station

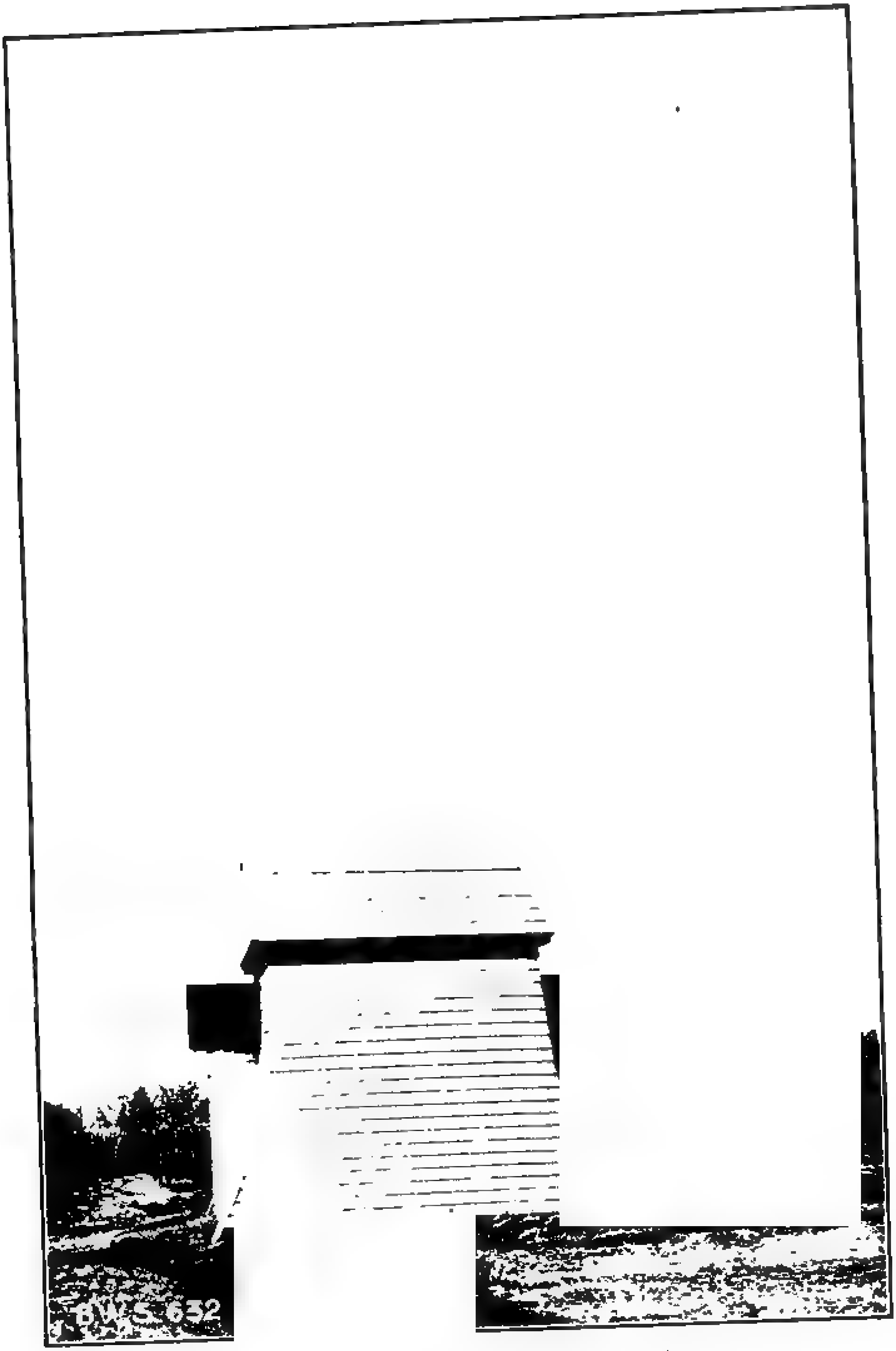
PLATE 50

Station "Raynor" (tower) at Manorville.

PLATE 51

Station "Farnsworth" (windmill) at Center Moriches.

... (water-tank) at East Moriches



Station "Wilkinson" (windmill) at Westhampton.

PLATE 54

Station "Hallock" (windmill) at Quogue.

TABLE 50

Primary Triangulation Stations

Station	Town	Co-ordinates North	Co-ordinates East	Azimuth De-grees	Azimuth Min-utes	Azimuth Sec-onds	Back Azimuth De-grees	Back Azimuth Min-utes	Back Azimuth Sec-onds	To Station	Distance Feet
Hospital	Amityville	4,905.896	150,964.724	36	31	31.9	216	31	31.9	St. Dominic	9,131.244
				86	07	21.1	266	07	21.1	Vulcanite	14,851.454
				103	27	00.3	283	27	00.3	Welwood	14,301.503
St. Dominic	Amityville	12,243.660	156,399.455	61	46	09.0	241	46	09.0	Belmont	18,612.721
				67	55	21.1	247	55	21.1	West Base	5,671.322
				93	19	12.1	273	19	12.1	East Base	10,988.490
				97	13	10.2	277	13	10.2	Sherman	22,466.511
				124	01	11.6	304	01	11.6	Vulcanite	11,320.262
				141	31	37.4	321	31	37.4	Welwood	13,621.458
West Base	Lindenhurst	14,375.282	161,654.930	154	00	28.7	334	00	28.7	Vulcanite	9,417.633
				115	50	39.8	295	50	39.8	East Base	6,349.653
*Welwood	Lindenhurst	1,579.393	164,873.977	22	08	49.1	202	08	49.1	Belmont	21,019.487
				60	25	10.3	240	25	10.3	Sherman	15,883.959
				109	33	07.4	289	33	07.4	Fire Island light	....
Vulcanite	Lindenhurst	5,910.196	165,782.178	24	52	01.3	204	52	01.3	Belmont	16,684.926
				74	47	04.0	254	47	04.0	Sherman	13,374.926
				191	50	37.4	11	50	37.4	Welwood	4,425.006
East Base	Lindenhurst	11,607.287	167,369.503	195	34	08.1	15	34	08.1	Vulcanite	5,914.088
Belmont	Babylon	21,048.060	172,797.985	67	23	42.6	247	23	42.6	Keith	16,390.813
				108	09	44.7	288	09	44.7	Bossert	22,139.265
Sherman	Babylon	9,420.438	178,687.672	333	08	11.9	153	08	11.9	Belmont	13,034.185
				27	16	17.5	207	16	17.5	Keith	20,160.781
				72	40	09.1	252	40	09.1	Bossert	15,866.878
Keith	Bayshore	27,348.248	187,929.628	58	04	10.4	238	04	10.4	Central Islip	28,697.758
				99	52	02.3	279	52	02.3	Islip	21,470.473
				155	54	08.2	335	54	08.2	Bossert	14,461.576
Bossert	Bayshore	14,146.993	193,834.207	33	01	48.7	213	01	48.7	Central Islip	33,849.892
				58	01	01.0	238	01	01.0	Islip	17,977.126
Islip	Islip	23,668.908	209,082.488	9	38	20.1	189	38	20.1	Central Islip	19,127.293
				42	30	52.7	222	30	52.7	Ronkonkoma	35,713.725
				74	48	56.5	254	48	56.5	Cutting	14,334.391
Central Islip	Central Islip	42,526.178	212,285.131	70	21	59.4	250	21	59.4	Ronkonkoma	22,224.067
				130	17	00.3	310	17	00.3	Oakdale	32,460.209
				144	51	25.3	324	51	25.3	Cutting	18,469.219
Cutting	Islip	27,423.442	222,916.440	24	31	53.7	204	31	53.7	Ronkonkoma	24,809.467
				112	36	39.1	292	36	39.1	Oakdale	15,307.771
Ronkonkoma	Islip	49,993.421	233,217.203	83	01	46.2	263	01	46.2	Holtsville	23,275.363
				116	32	58.2	296	32	58.2	Patchogue	31,827.456
				172	19	59.8	352	19	59.8	Oakdale	28,711.847

TABLE 50 (*Concluded*)

Station	Town	Co-ordinates North	Co-ordinates East	Azimuth De-grees	Azimuth Min-utes	Azimuth Sec-onds	Back Azimuth De-grees	Back Azimuth Min-utes	Back Azimuth Sec-onds	To Station	Distance Feet
Oakdale	Islip	21,538.058	237,047.616	31	38	20.5	211	38	20.5	Holtsville	36,740.598
				59	59	41.8	239	59	41.8	Patchogue	28,454.131
Holtsville	Brookhaven	52,817.897	256,320.493	81	36	00.5	261	36	00.5	Plainfield	21,027.758
				121	02	45.6	301	02	45.6	Bellport	36,009.000
				162	31	29.8	342	31	29.8	Patchogue	17,875.599
Patchogue	Brookhaven	35,767.297	261,688.366	37	29	20.6	217	29	20.6	Plainfield	25,359.872
				93	24	50.1	273	24	50.1	Bellport	25,528.192
Plainfield	Brookhaven	55,889.584	277,122.633	57	43	28.7	237	43	28.7	Yaphank	19,288.228
				103	11	41.4	283	11	41.4	Mastic	30,300.455
				155	05	40.2	335	05	40.2	Bellport	23,861.495
Bellport	Brookhaven	34,247.125	287,171.254	11	05	13.9	191	05	13.9	Yaphank	32,549.712
				52	52	20.9	232	52	20.9	Mastic	24,397.356
Yaphank	Brookhaven	66,189.324	293,430.650	93	27	14.5	273	27	14.5	Raynor	22,189.267
				119	27	14.9	299	27	14.9	Farnsworth	38,194.735
				142	32	15.5	322	32	15.5	Mastic	21,689.582
Mastic	Brookhaven	48,973.149	306,623.116	29	25	29.0	209	25	29.0	Raynor	18,231.024
				94	27	37.5	274	27	37.5	Farnsworth	20,126.578
Raynor	Brookhaven	64,852.408	315,579.649	80	43	44.0	260	43	44.0	Terry	16,581.667
				122	10	09.2	302	10	09.2	Convent	27,170.108
				147	30	36.1	327	30	36.1	Farnsworth	20,681.456
Farnsworth	Brookhaven	47,407.898	326,688.736	14	38	35.6	194	38	35.6	Terry	20,791.203
				75	56	10.8	255	56	10.8	Convent	12,257.268
*Terry	Brookhaven	67,523.778	331,944.736	55	43	02.1	235	43	02.1	Osborne	18,967.595
				116	48	45.1	296	48	45.1	Wilkinson	33,190.177
				124	53	11.1	304	53	11.1	East Base	17,593.004
				151	32	42.0	331	32	42.0	West Base	9,691.120
				158	50	18.9	338	50	18.9	Convent	18,376.547
West Base	Brookhaven	59,003.427	336,562.249	29	55	35.2	209	55	35.2	Osborne	22,158.890
				99	48	34.6	279	48	34.6	East Base	10,259.105
Convent	Brookhaven	50,386.414	338,578.608	17	59	51.7	197	59	51.7	Osborne	29,252.692
				84	37	01.1	264	37	01.1	Wilkinson	23,089.790
East Base	Southampton	57,255.535	346,671.360	02	35	03.5	182	35	03.5	Osborne	20,973.595
*Osborne	Southampton	78,207.741	347,617.066	93	13	43.5	273	13	43.5	Oakville	28,423.657
				128	05	41.2	308	05	41.2	Hallock	38,241.184
				151	27	56.7	331	27	56.7	Wilkinson	29,202.350
Wilkinson	Southampton	52,552.546	361,566.566	30	57	27.2	210	57	27.2	Oakville	28,050.078
Oakville	Southampton	76,606.850	375,995.613	175	32	09.7	355	32	09.7	Hallock	22,059.465
Hallock	Southampton	54,614.306	377,712.551	262	43	22.8	82	43	22.8	Wilkinson	16,277.084

*United States Coast Survey station

TABLE 51

Secondary Triangulation Stations

Station	Location	Co-ordinates North	Co-ordinates East	Azimuth De-grees	Azimuth Min-utes	Azimuth Sec-onds	Back Azimuth De-grees	Back Azimuth Min-utes	Back Azimuth Sec-onds	To Station	Distance Feet
Slender	Amityville	11,560.03	149,994.41	83	54	27.6	263	54	27.6	St. Dominic	6,441.42
				109	41	25.2	289	41	25.2	Vulcanite	16,768.21
Monahan	Amityville	8,168.06	152,715.89	42	06	26.9	222	06	26.9	St. Dominic	5,493.57
				208	13	38.6	28	13	38.6	Hospital	3,702.47
Copiague	Copiague	4,716.46	155,847.05	4	11	50.3	184	11	50.3	St. Dominic	7,547.44
				83	08	55.0	263	08	55.0	Vulcanite	10,006.59
Red House	Lindenhurst	5,927.89	159,525.91	90	09	43.3	270	09	43.3	Vulcanite	6,256.30
				129	06	52.0	309	06	52.0	Welwood	6,892.84
Lindenhurst road	Lindenhurst	11,226.49	161,477.53	141	00	09.5	321	00	09.5	Vulcanite	6,840.53
				281	19	36.6	101	19	36.6	St. Dominic	5,178.95
Green House	West Babylon	14,029.25	169,425.90	204	10	11.6	24	10	11.6	Vulcanite	8,899.20
				262	11	41.6	82	11	41.6	St. Dominic	13,148.25
Anderson	West Babylon	7,406.75	172,265.62	231	44	55.7	51	44	55.7	Welwood	9,412.46
				257	00	08.2	77	00	08.2	Vulcanite	6,653.92
Blatchford	West Babylon	12,585.00	172,627.67	225	43	23.8	45	43	23.8	Vulcanite	9,561.06
				268	47	42.1	88	47	42.1	St. Dominic	16,231.81
Cockerill	Babylon	16,945.96	179,441.91	185	43	23.9	5	43	23.9	Sherman	7,563.32
				301	41	31.7	121	41	31.7	Belmont	7,808.27
Housman	North Babylon	23,590.30	179,801.23	183	05	43.8	3	05	43.8	Cockerill	6,654.06
				250	02	55.1	70	02	55.1	Belmont	7,450.40
Paddle	North Babylon	29,494.49	180,549.38	187	13	18.2	7	13	18.2	Housman	5,951.40
				222	32	34.7	42	32	34.7	Belmont	11,464.13
Sammis	West Islip	20,316.13	185,276.48	125	47	14.2	305	47	14.2	Bossert	10,549.54
				273	21	24.7	93	21	24.7	Belmont	12,499.94
				202	04	28.8	22	04	28.8	Higbie	512.36
Higbie	West Islip	20,790.90	185,469.03	20	34	05.7	200	34	05.7	Keith	7,003.80
				128	27	28.2	308	27	28.2	Bossert	10,682.59
Horn	West Islip	14,833.15	186,706.27	95	29	54.8	275	29	54.8	Bossert	7,160.88
				294	04	38.8	114	04	38.8	Belmont	15,233.70
Thompson	West Islip	25,190.36	190,484.18	163	07	29.0	343	07	29.0	Bossert	11,540.33
				310	11	19.0	130	11	19.0	Keith	3,343.99
Hyde	Bayshore	21,859.78	191,888.47	165	50	28.2	345	50	28.2	Bossert	7,954.43
				324	11	49.4	144	11	49.4	Keith	6,767.25
Electric	Bayshore	20,916.60	195,855.32	196	37	24.2	16	37	24.2	Bossert	7,064.88
				309	03	32.8	129	03	32.8	Keith	10,206.99
St. Joseph	Brentwood	37,835.27	201,107.06	197	04	03.7	17	04	03.7	Bossert	24,779.61
				231	29	09.9	51	29	09.9	Keith	16,841.08
Race	Bayshore	25,537.52	202,382.92	216	53	19.0	36	53	19.0	Bossert	14,241.65
				277	08	27.3	97	08	27.3	Keith	14,566.27
Orowoc	Islip	30,328.09	205,330.04	150	35	55.5	330	35	55.5	Islip	7,643.66
				260	16	56.2	80	16	56.2	Keith	17,653.73

TABLE 51 (*Continued*)

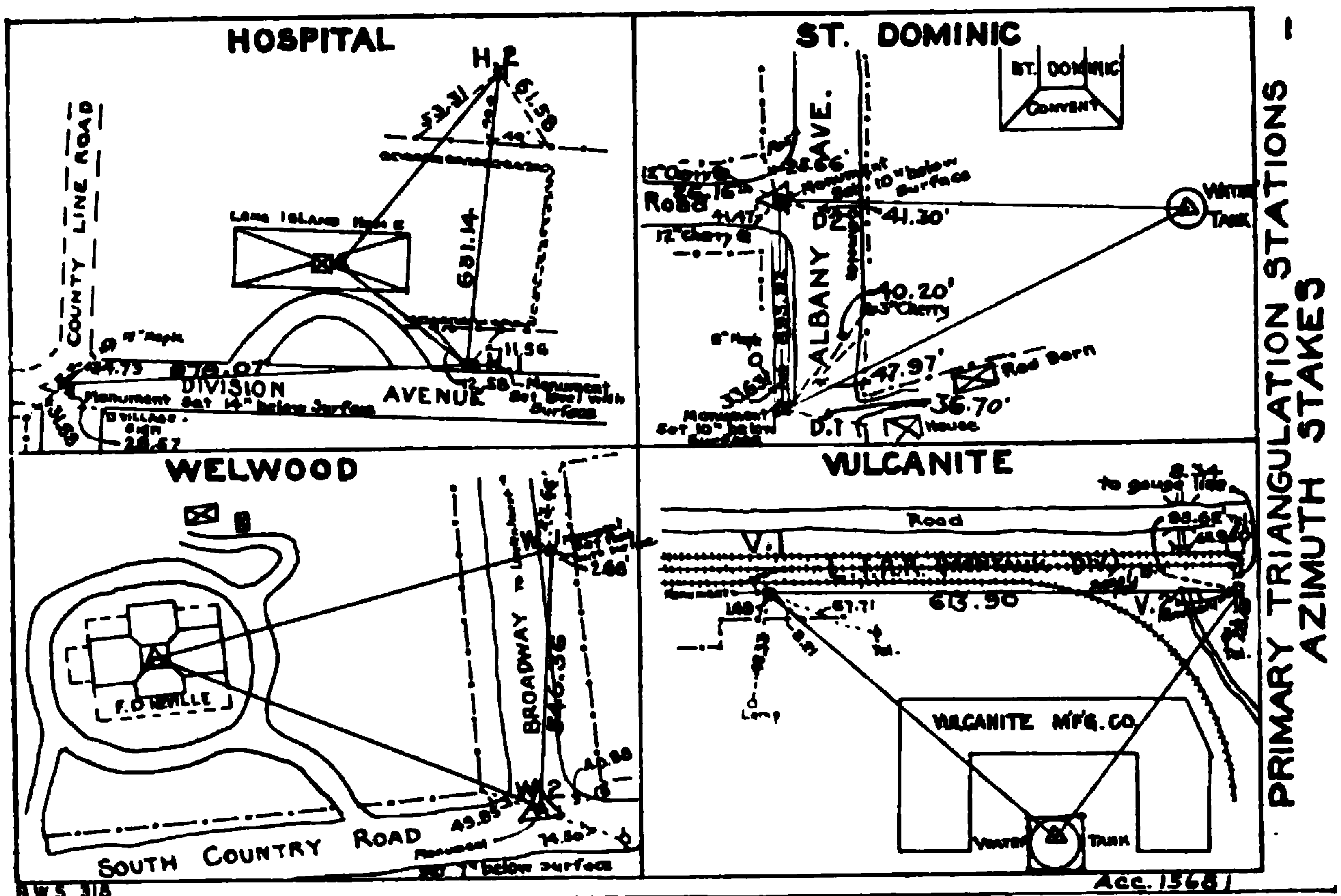
Station	Location	Co-ordinates North	Co-ordinates East	Azimuth De-grees	Azimuth Min-utes	Azimuth Sec-onds	Back Azimuth De-grees	Back Azimuth Min-utes	Back Azimuth Sec-onds	To Station	Distance Feet
Fire Line No. 1	Great River	29,781.64	220,736.08	242	19	16.9	62	19	16.9	Islip	13,159.52
				326	27	05.4	146	27	05.4	Central Islip	15,291.90
				351	40	42.9	171	40	42.9	Fire Line No. 2	3,870.20
				351	32	23.4	171	32	23.4	24–L	788.14
Fire Line No. 2	Great River	33,610.88	220,176.00	228	08	00.2	48	08	00.2	Islip	14,896.60
				318	29	17.5	138	29	17.5	Central Islip	11,905.82
				171	42	50.6	351	42	50.6	24–L	3,081.55
Carleton	East Islip	30,582.54	212,299.51	204	57	11.8	24	57	11.8	Islip	7,625.46
				106	34	14.0	286	34	14.0	Cutting	11,076.95
Cutts	Great River	31,735.69	217,397.78	225	52	08.4	45	52	08.4	Islip	11,585.22
				128	00	14.1	308	00	14.1	Cutting	7,003.65
Southside	Great River	30,112.89	225,238.46	313	46	49.5	133	46	49.5	Central Islip	17,899.71
24–L	Great River	30,561.40	220,620.10	21	51	01.1	201	51	01.1	Ronkonkoma	21,421.97
Connetquot	Great River	18,209.71	227,031.75	328	45	55.7	148	45	55.7	Central Islip	28,438.60
				11	00	44.6	191	00	44.6	Ronkonkoma	32,380.22
North Bourne	Oakdale	31,297.10	238,439.72	145	05	28.4	325	05	28.4	South Bourne	2,285.91
				188	07	05.9	8	07	05.9	Oakdale	9,857.84
				137	36	13.6	317	36	13.6	Sayville school	8,497.35
South Bourne	Oakdale	29,420.60	239,745.14	134	50	12.0	314	50	12.0	Sayville school	6,238.65
				198	53	30.2	18	53	30.2	Oakdale	8,331.35
South Duncan	Sayville	32,807.02	243,306.54	80	51	05.1	260	51	05.1	Patchogue	18,618.62
				209	03	38.3	29	03	38.3	Oakdale	12,890.48
Sayville school	Sayville	25,021.81	244,169.09	58	28	37.3	238	28	37.3	Patchogue	20,552.15
				23	36	47.3	203	36	47.3	Holtsville	30,336.11
North Duncan	Sayville	33,499.84	244,225.38	232	58	59.3	52	58	59.3	South Duncan	1,150.77
				82	36	06.8	262	36	06.8	Patchogue	17,609.51
				32	03	03.1	212	03	03.1	Holtsville	22,792.09
Mill	Holbrook	45,543.14	249,197.91	44	23	39.8	224	23	39.8	Holtsville	10,181.03
				128	02	56.5	308	02	56.5	Patchogue	15,861.22
North Broadway	Bayport	35,962.14	249,334.65	169	27	40.0	349	27	40.0	South Broadway	2,980.71
				22	30	41.4	202	30	41.4	Holtsville	18,246.05
				90	54	13.1	270	54	13.1	Patchogue	12,356.26
South Broadway	Bayport	33,031.71	249,879.83	76	57	24.7	256	57	24.7	Patchogue	12,121.26
				153	58	32.7	333	58	32.7	Bayport school	7,125.01
Bayport school	Bayport	26,628.99	253,006.07	07	12	46.5	187	12	46.5	Holtsville	26,397.81
				43	32	03.1	223	32	03.1	Patchogue	12,605.19
Mott	Patchogue	42,431.24	257,477.40	247	42	39.8	327	42	39.8	Patchogue	7,882.92
				353	38	39.8	173	38	39.8	Holtsville	10,450.89
Patchogue school	Patchogue	34,350.76	264,323.65	298	06	25.8	118	06	25.8	Patchogue	2,987.62
				336	33	33.1	156	33	33.1	Holtsville	20,108.49

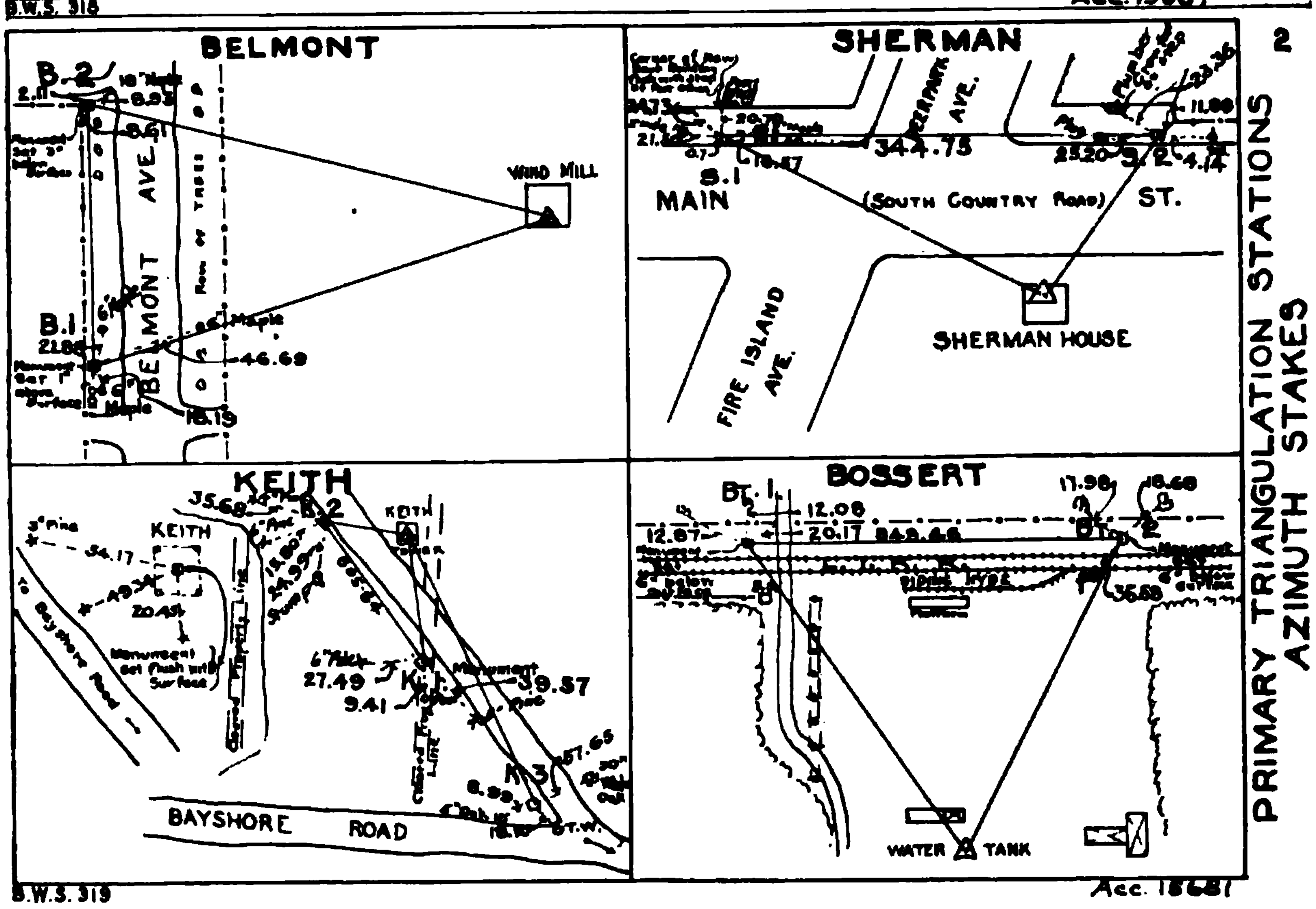
TABLE 51 (*Continued*)

Station	Location	Co-ordinates North	Co-ordinates East	Azimuth De-grees	Azimuth Min-utes	Azimuth Sec-onds	Back Azimuth De-grees	Back Azimuth Min-utes	Back Azimuth Sec-onds	To Station	Distance Feet
Summers	Patchogue	36,388.20	269,018.28	265	09	33.9	85	09	33.9	Patchogue	7,356.06
				22	34	00.2	202	34	00.2	Plainfield	21,118.37
				96	43	39.8	276	43	39.8	Bellport	18,278.74
South Glover	East Patchogue	44,031.01	271,111.71	300	42	46.5	120	42	46.5	Holtsville	17,204.35
				228	45	04.2	48	45	04.2	Patchogue	12,533.48
North Glover	East Patchogue	44,844.56	271,123.46	180	49	41.3	00	49	41.3	South Glover	813.63
				298	18	29.8	118	18	29.8	Holtsville	16,813.75
				226	06	26.5	46	06	26.5	Patchogue	13,092.66
Robinson	Hagerman	40,624.38	276,185.86	03	30	41.9	183	30	41.9	Plainfield	15,293.91
				251	28	39.5	71	28	39.5	Patchogue	15,289.49
				120	08	10.0	300	08	10.0	Bellport	12,702.30
Hill	Yaphank	68,709.94	279,495.37	134	29	16.6	314	29	16.6	Poor Farm	14,862.95
				190	29	07.6	10	29	07.6	Plainfield	13,038.08
Hank	Yaphank	66,755.77	280,901.05	132	36	44.1	312	36	44.1	Poor Farm	12,497.44
				199	10	25.4	19	10	25.4	Plainfield	11,504.37
Bellport—M. 1	Bellport	42,942.45	281,765.83	59	34	56.4	239	34	56.4	Bellport—M. 2	3,855.12
				131	23	05.5	311	23	05.5	Bellport—M. 3	4,304.51
				148	07	58.8	328	07	58.8	Bellport	10,238.52
Bellport—M. 3	Bellport	40,096.69	284,995.44	159	35	48.3	339	35	48.3	Bellport	6,241.12
Bellport—M. 2	Bellport	44,894.29	285,090.32	168	56	28.5	348	56	28.5	Bellport	10,848.62
				181	07	58.6	01	07	58.6	Bellport—M. 3	4,798.55
Bellport church	Bellport	33,635.59	285,690.03	275	04	31.5	95	04	31.5	Patchogue	24,096.14
				303	09	36.4	123	09	36.4	Holtsville	35,086.46
Yap	Yaphank	67,365.67	286,225.18	156	52	31.1	336	52	31.1	Poor Farm	9,862.53
				99	16	19.7	279	16	19.7	Yaphank	7,300.87
Poor Farm	Yaphank	58,294.59	290,098.57	259	29	59.0	79	29	59.0	Plainfield	13,196.94
				22	52	58.2	202	52	58.2	Yaphank	8,569.10
North Brook	Yaphank	54,010.99	290,797.67	12	11	58.8	192	11	58.8	Yaphank	12,459.28
				66	22	18.5	246	22	18.5	Raynor	27,049.62
South Brook	Yaphank	51,675.90	291,098.84	352	39	03.2	172	39	03.2	North Brook	2,354.43
				09	07	38.9	189	07	38.9	Yaphank	14,699.45
				61	42	32.0	241	42	32.0	Raynor	2,768.24
West Hawkins	Brookhaven	45,483.76	292,348.33	17	08	01.3	197	08	01.3	East Hawkins	1,559.76
				02	59	32.1	182	59	32.1	Yaphank	20,733.17
				50	10	51.2	230	10	51.2	Raynor	30,246.17
East Hawkins	Brookhaven	46,974.30	292,807.83	01	51	23.3	181	51	23.3	Yaphank	19,225.12
				51	51	52.0	231	51	52.0	Raynor	28,951.39
West Haven	Paynville	58,499.50	305,530.39	173	27	19.0	353	27	19.0	Mastic	9,588.70
				57	41	59.9	237	41	59.9	Raynor	11,889.09
East Haven	Paynville	58,042.56	306,029.16	312	29	40.1	132	29	40.1	West Haven	676.44
				176	15	21.9	356	15	21.9	Mastic	9,089.11
				54	30	35.4	234	30	35.4	Raynor	11,729.06
Payne	Paynville	51,218.61	307,078.56	317	38	47.0	137	38	47.0	Yaphank	20,257.96
				31	56	41.2	211	56	41.2	Raynor	16,067.01
West Wheatling	Moriches	53,188.60	313,876.78	08	18	22.5	188	18	22.5	Raynor	11,787.46
				51	36	09.8	231	36	09.8	Terry No. 2	23,067.77

TABLE 51 (*Concluded*)

Station	Location	Co-ordinates North	Co-ordinates East	Azimuth De-grees	Azimuth Min-utes	Azimuth Sec-onds	Back Azimuth De-grees	Back Azimuth Min-utes	Back Azimuth Sec-onds	To Station	Distance Feet
East Wheatling	Moriches	53,498.37	314,609.85	247	05	35.2	67	05	35.2	West Wheatling	795.82
				04	52	55.4	184	52	55.4	Raynor	11,395.39
				51	03	24.0	231	03	24.0	Terry No. 2	22,301.87
Prospect	Moriches	56,950.48	315,175.63	02	55	37.1	182	55	37.1	Raynor	7,912.25
				57	48	09.8	237	48	09.8	Terry No. 2	19,829.24
Forge	Center Moriches	51,909.54	321,185.14	336	26	12.0	156	26	12.0	Raynor	14,022.04
				34	45	54.5	214	45	54.5	Terry No. 2	18,888.33
West Center	Center Moriches	50,512.05	326,325.96	72	52	09.7	252	52	09.7	East Center	2,531.38
				173	20	01.9	353	20	01.9	Farnsworth	3,125.29
East Center	Center Moriches	51,257.67	328,745.02	208	06	28.8	28	06	28.8	Farnsworth	4,364.53
Reeve	East Moriches	57,602.78	332,319.29	208	54	41.0	28	54	41.0	Farnsworth	8,164.64
				139	03	44.4	319	03	44.4	Convent	9,552.75
Roman Catholic church	East Moriches	53,622.03	335,078.73	299	56	22.3	119	56	22.3	Raynor	22,501.09
				347	19	52.8	167	19	52.8	Terry No. 2	14,240.09
Steinker	Eastport	61,329.64	339,093.12	310	55	02.4	130	55	02.4	Terry No. 2	9,446.10
				26	47	42.5	206	47	42.5	Osborn	18,909.60
Seatuck	Eastport	64,953.07	345,040.89	281	04	57.0	101	04	57.0	Terry No. 2	13,333.02
				10	59	55.9	190	59	55.9	Osborn	13,502.30
Bald road	Eastport	66,933.97	349,226.67	271	55	50.3	91	55	50.3	Terry No. 2	17,280.90
				351	52	28.4	171	52	28.4	Osborn	11,388.09
Fordham	Speonk	56,503.92	349,234.73	302	30	35.8	122	30	35.8	Terry No. 2	20,489.98
				355	44	14.7	175	44	14.7	Osborn	21,764.03
Remson	Speonk	60,763.80	350,323.76	290	11	01.6	110	11	01.6	Terry No. 2	19,569.04
				351	10	47.9	171	10	47.9	Osborn	17,652.40
Westhampton	Westhampton	55,298.29	356,988.91	41	43	55.8	221	43	55.8	Oakville	28,553.37
				91	53	25.3	271	53	25.3	Hallock	20,734.07
Beaver	Westhampton	61,378.58	357,690.71	329	05	45.6	149	05	45.6	Osborn	19,613.26
				50	14	31.8	230	14	31.8	Oakville	23,811.13
Marcher	Center Moriches	56,148.80	324,323.18	314	52	08.1	134	52	08.1	Raynor	12,337.02
				33	52	41.8	213	52	41.8	Terry No. 2	13,692.02
East spire	Riverhead	93,045.41	357,639.03	214	02	12.0	34	02	12.0	Osborn	17,905.20
				131	50	41.5	311	50	41.5	Oakville	24,641.24
Deacon	Westhampton	66,308.48	358,102.98	318	36	45.8	138	36	45.8	Osborn	15,860.23
				60	04	36.4	240	04	36.4	Oakville	20,644.32
Court House	Riverhead	92,463.27	359,732.78	220	21	39.8	40	21	39.8	Osborn	18,708.57
				134	16	30.2	314	16	30.2	Oakville	22,713.56
Tower mill	Riverhead	91,407.81	360,454.16	224	12	04.7	44	12	04.7	Osborn	18,413.16
				133	36	07.3	313	36	07.3	Oakville	21,463.40
Hampton	Westhampton	63,436.64	365,353.92	309	47	14.1	129	47	14.1	Osborn	23,082.06
				38	56	19.0	218	56	19.0	Oakville	16,932.21
West head	Oakville	76,923.36	368,604.63	92	27	07.8	272	27	07.8	Oakville	7,397.75
				325	46	40.6	145	46	40.6	East spire	19,497.19
Oak	Oakville	69,738.38	375,300.40	05	46	46.9	185	46	46.9	Oakville	6,903.58
				170	56	16.2	350	56	16.2	Hallock	15,315.23


HOSPITAL
H.2
DIVISION AVENUE
COUNTY LINE ROAD
631.14
ST. DOMINIC
ST. DOMINIC CONVENT
ALBANY AVE.
WATER TANK
41.30'
10.20'
47.97'
36.70'
WELWOOD
F. O. NEVILLE
BROADWAY
SOUTH COUNTRY ROAD
VULCANITE
Road
613.90
VULCANITE MFG. CO.
WATER TANK
PRIMARY TRIANGULATION STATIONS
AZIMUTH STAKES
B.W.S. 318
Acc. 15681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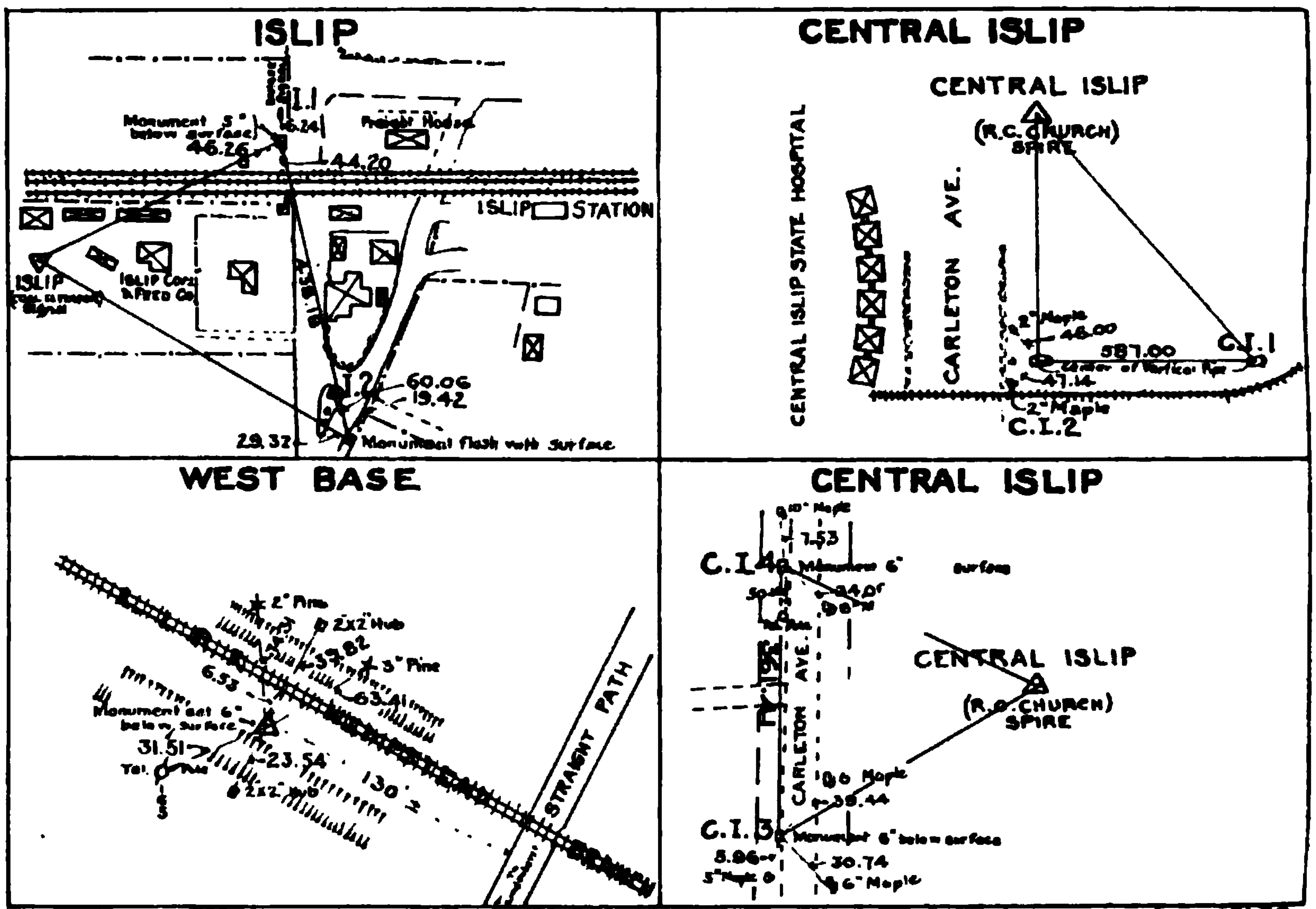
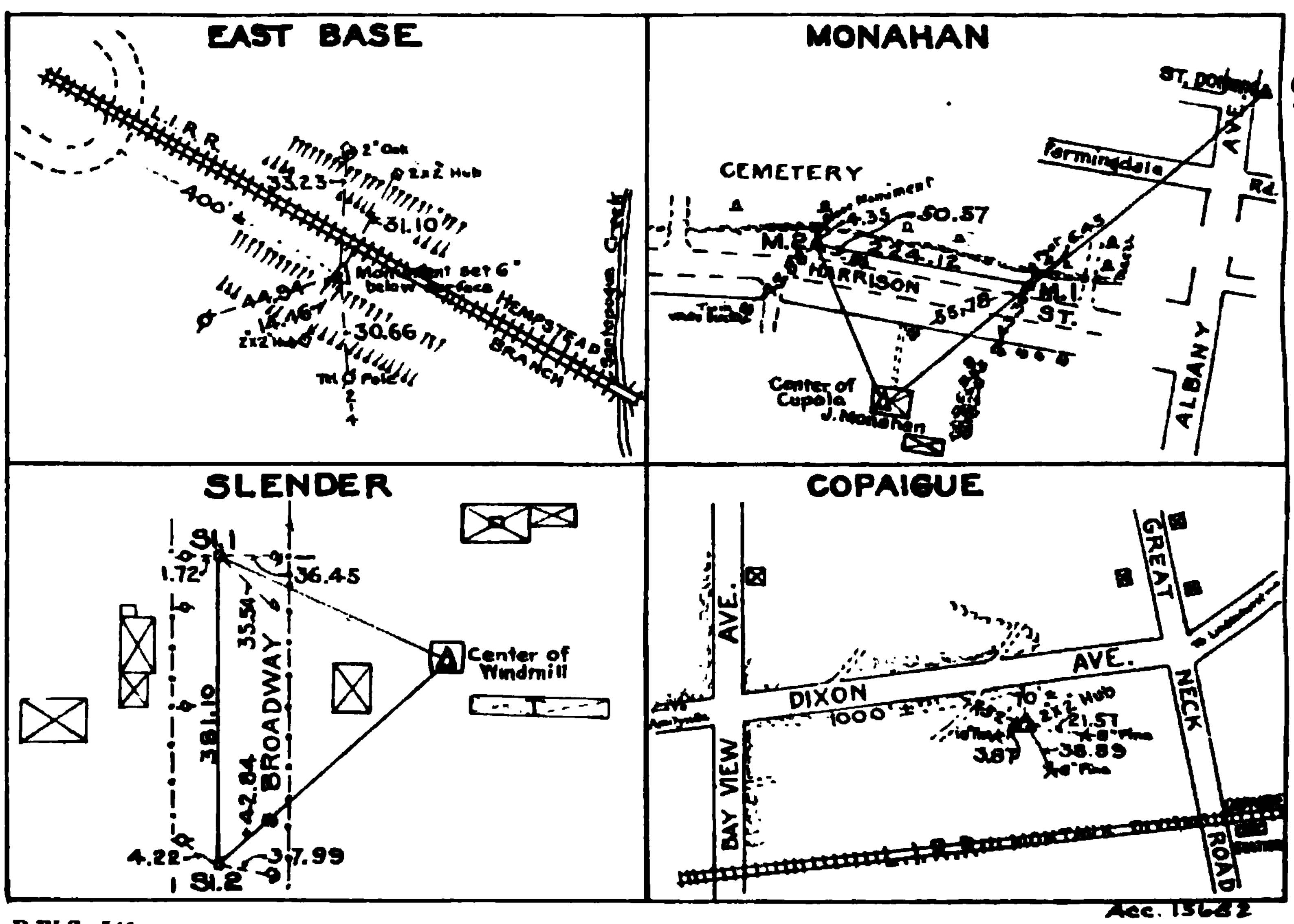
B.2
B.1
BELMONT AVE.
WIND MILL
46.69
SHERMAN
MAIN
(SOUTH COUNTRY ROAD) ST.
344.75
FIRE ISLAND AVE.
SHERMAN HOUSE
KEITH
BAYSHORE ROAD
39.57
27.49
9.41
BOSSERT
WATER TANK
PRIMARY TRIANGULATION STATIONS
AZIMUTH STAKES
B.W.S. 319
Acc. 15681

SHEET 157



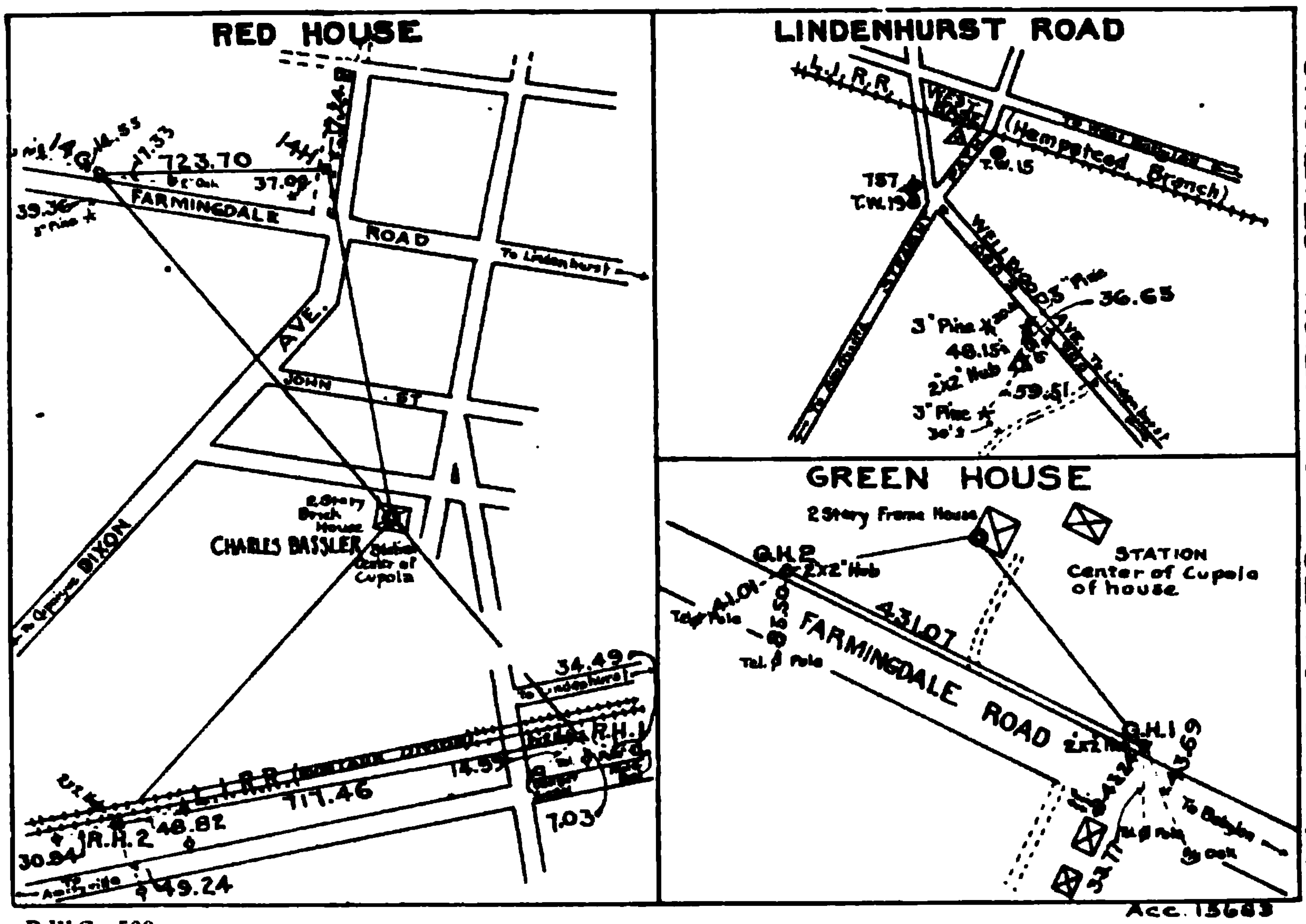
PRIMARY TRIANGULATION STATIONS AZIMUTH STAKES

B.W.S. 540



SECONDARY TRIANGULATION STATIONS AZIMUTH STAKES

B.W.S. 541



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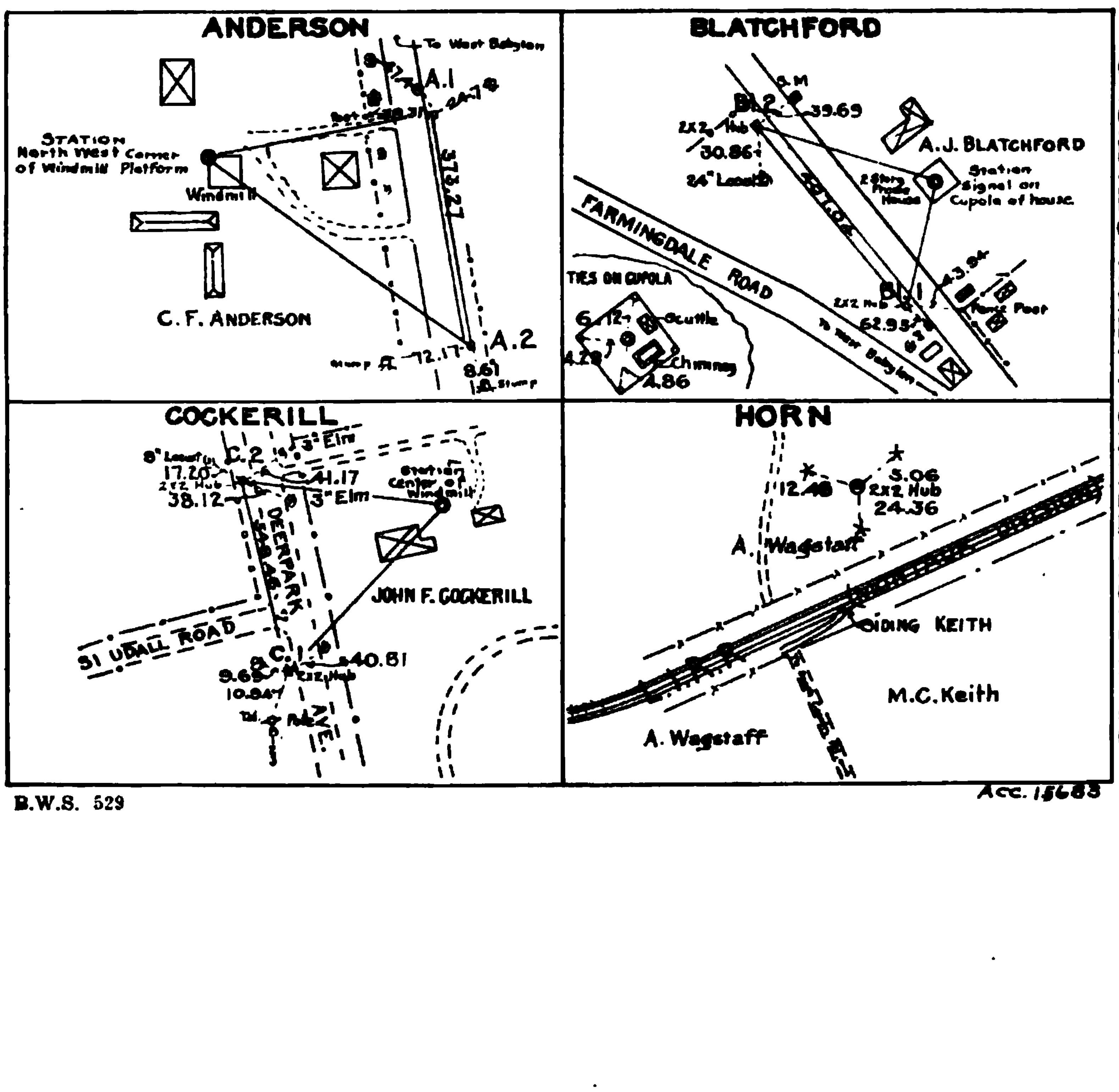
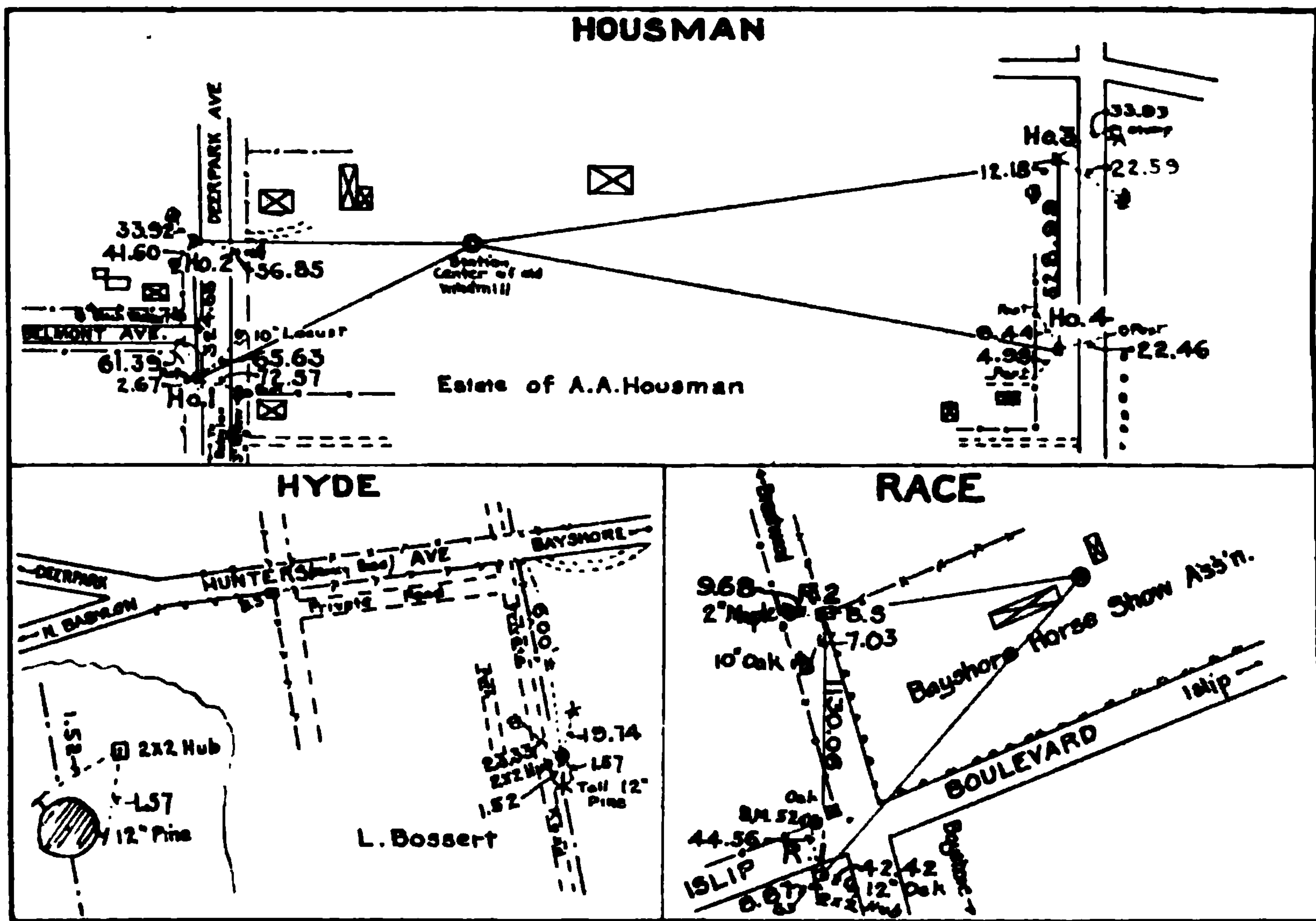


B.W.S. 529

SHEET 159



SECONDARY TRIANGULATION STATIONS AZIMUTH STAKES

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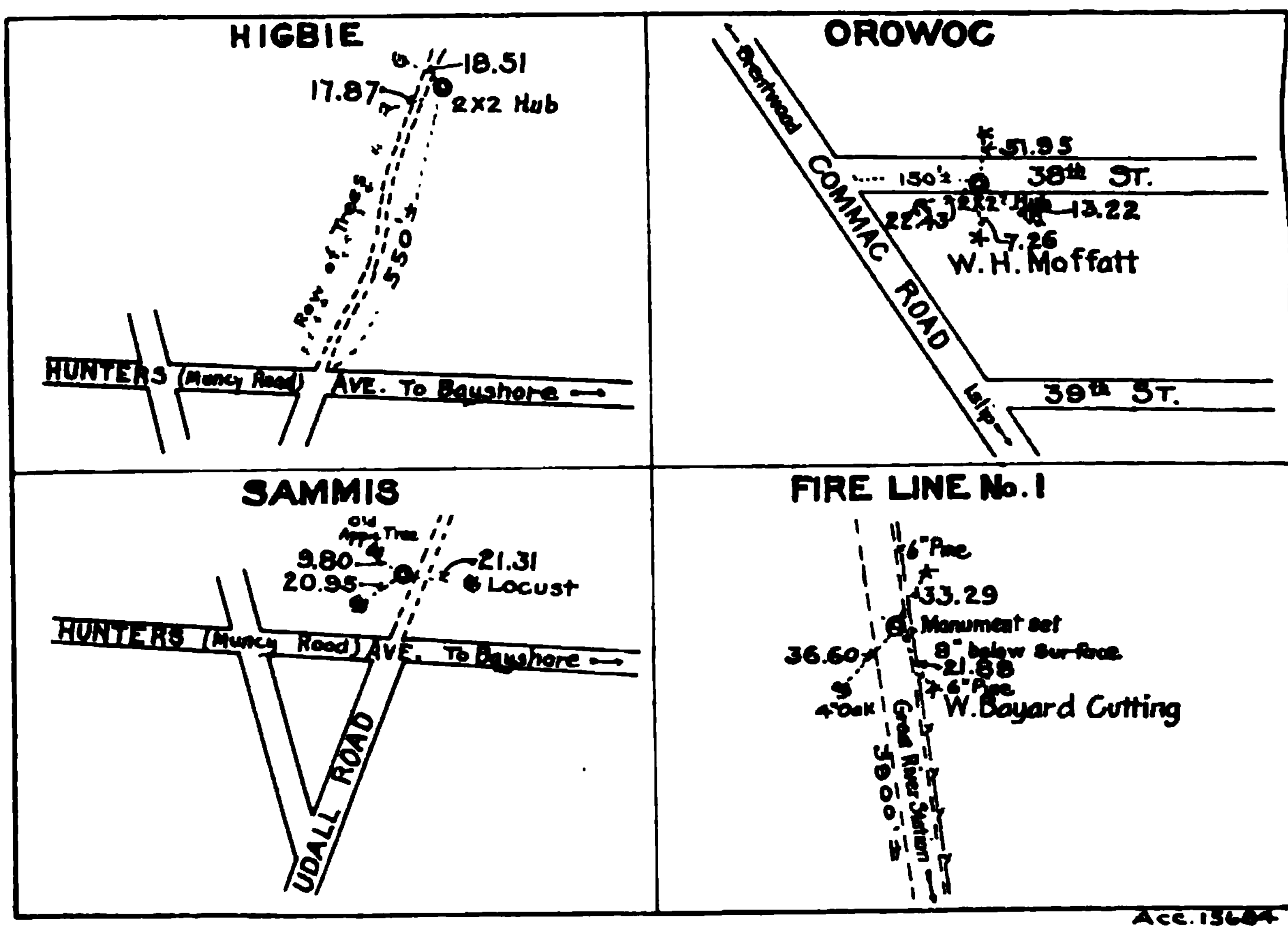

SECONDARY TRIANGULATION STATIONS AZIMUTH STAKES

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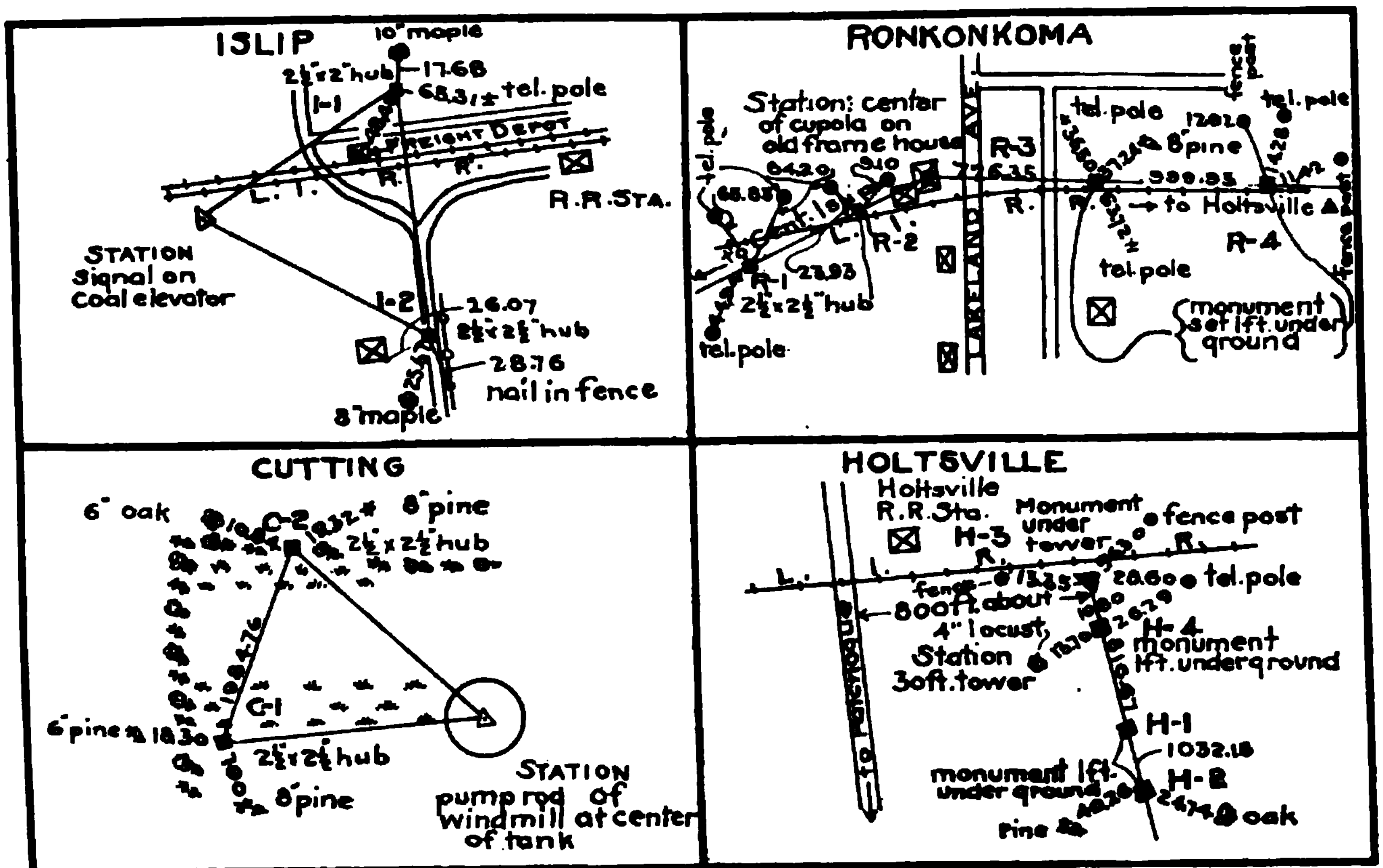

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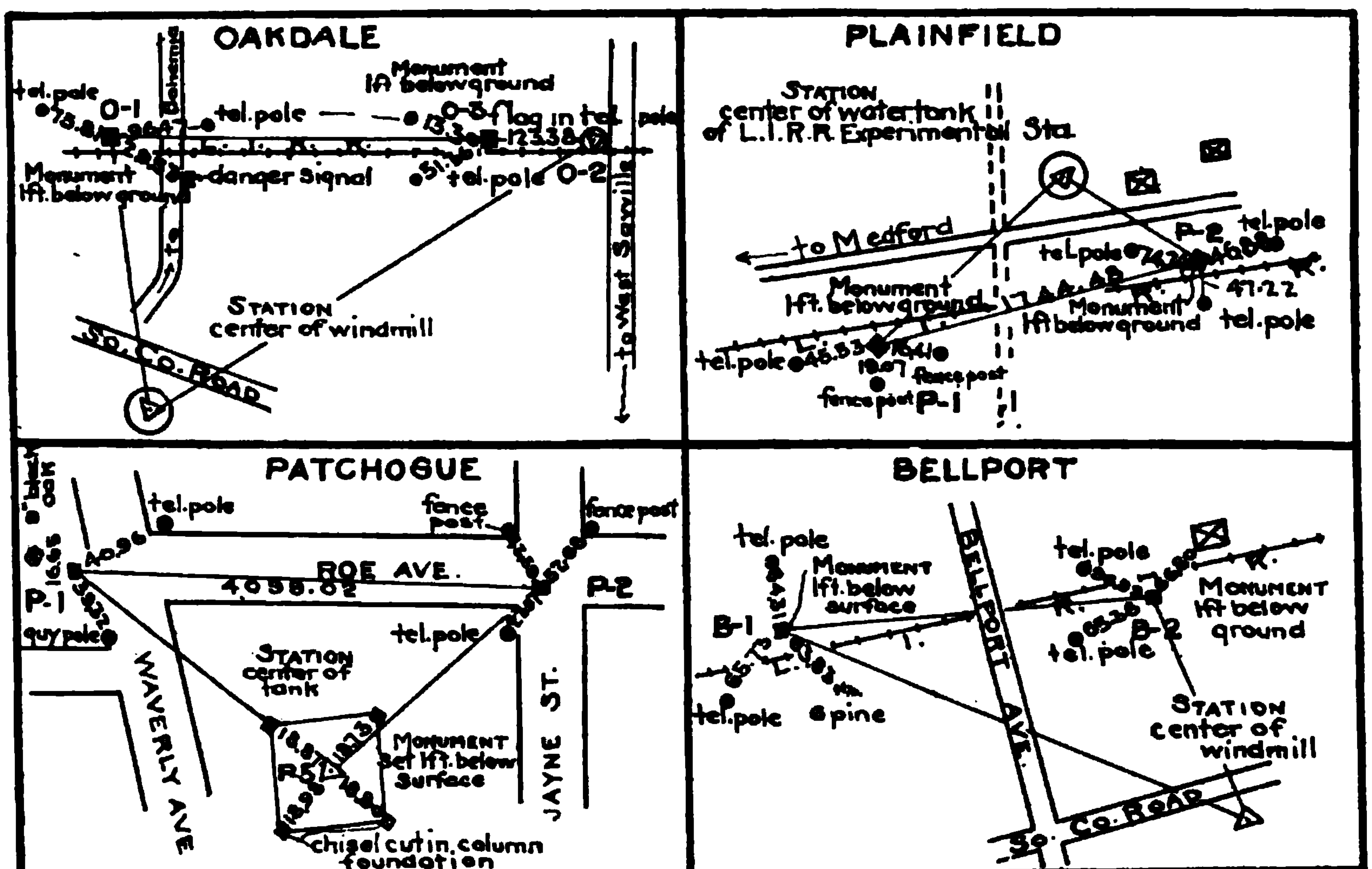
Acc L 430

PRIMARY TRIANGULATION STATIONS
AZIMUTH STAKES



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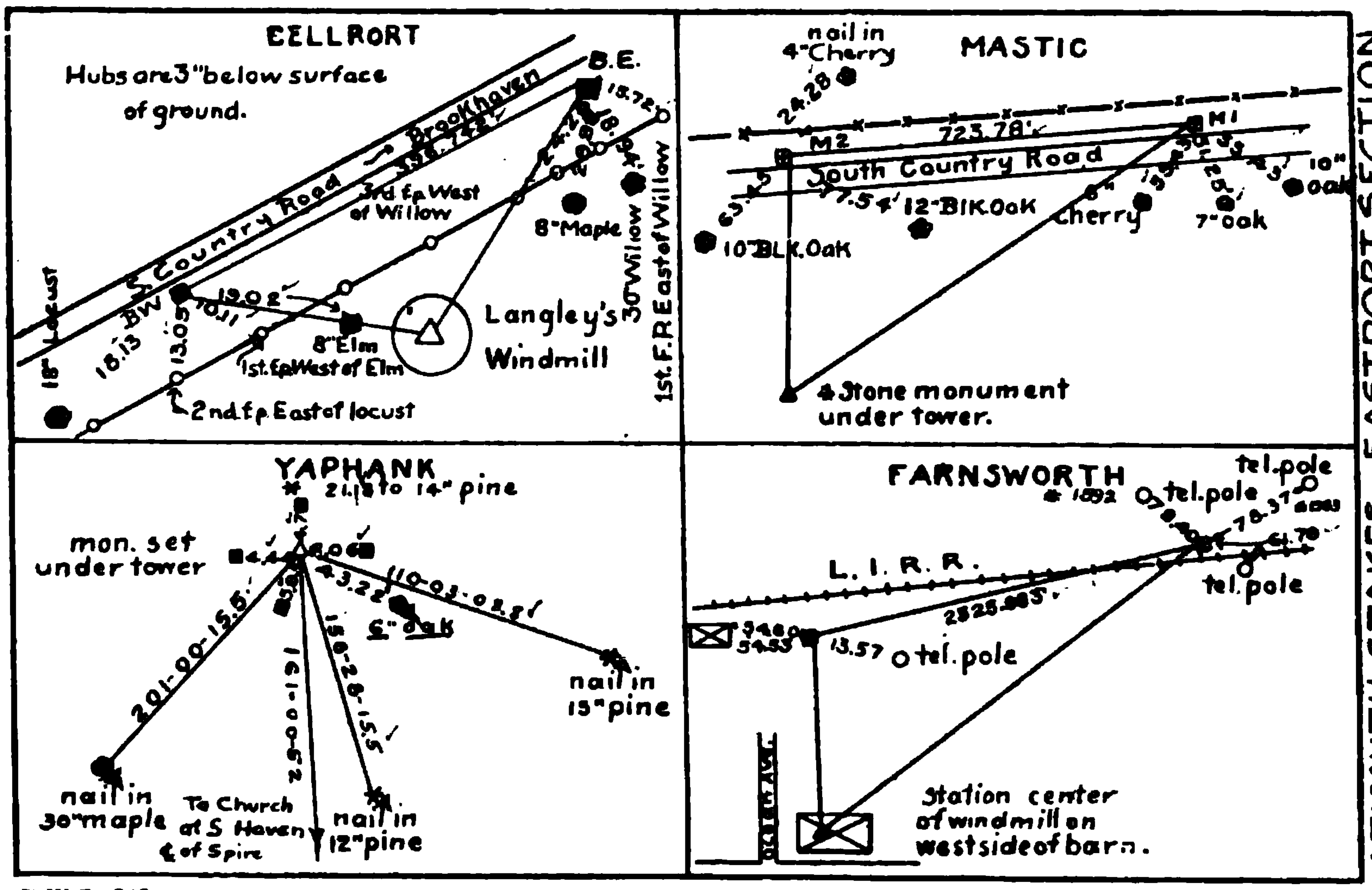
Acc. L 430

PRIMARY TRIANGULATION STATIONS
AZIMUTH STAKES

SHEET 161



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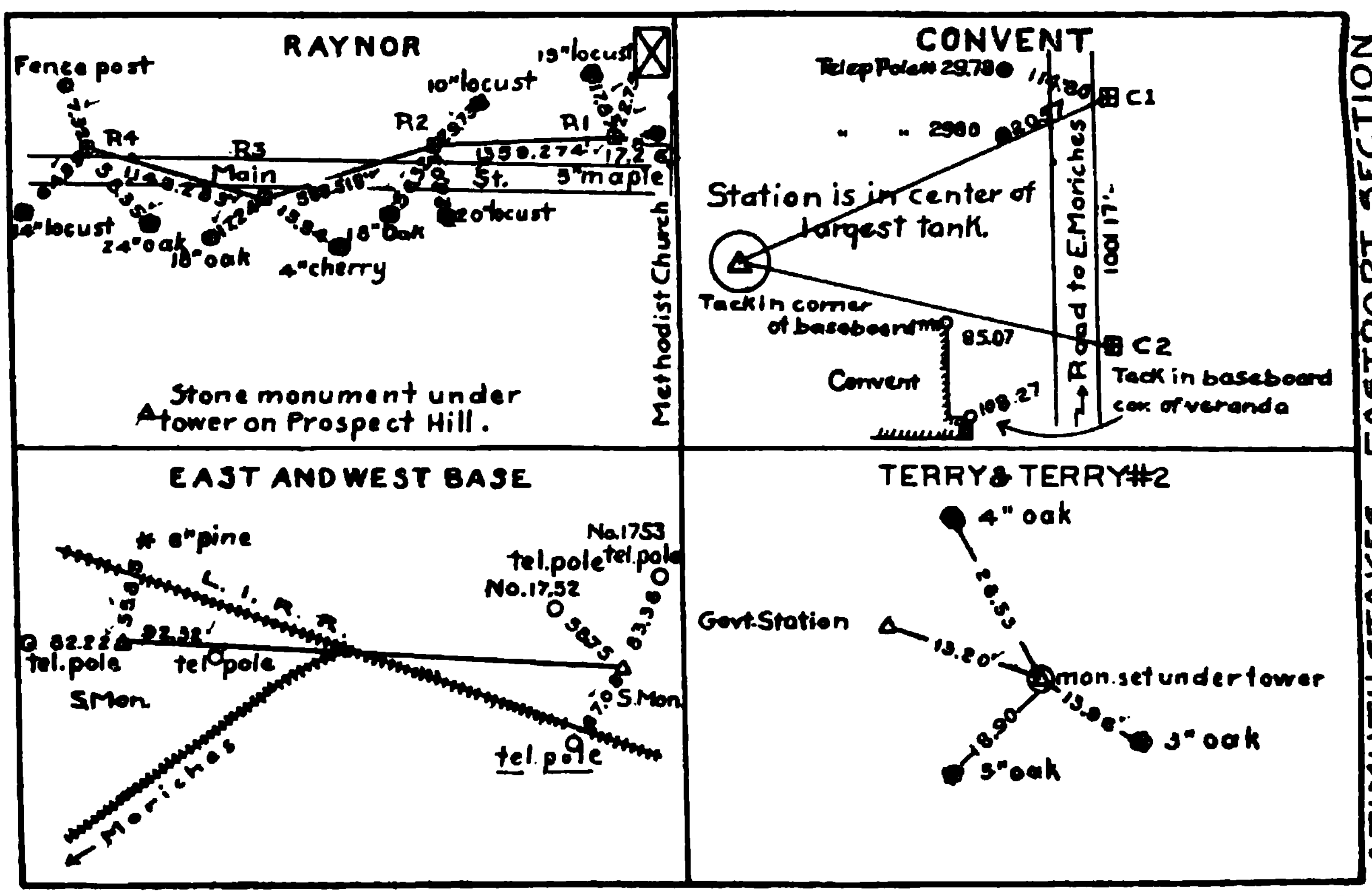

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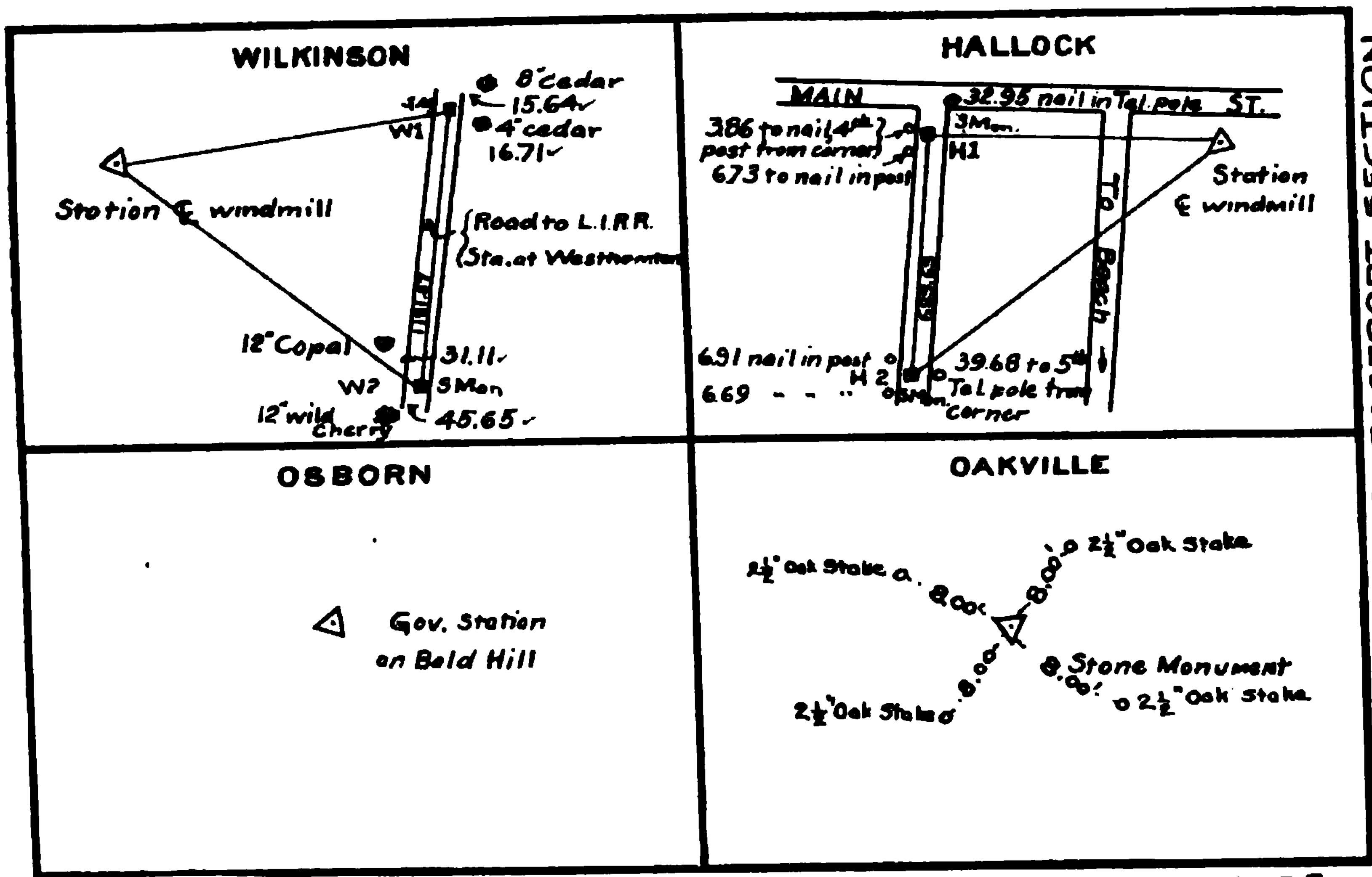
AZIMUTH STAKES—EASTPORT SECTION



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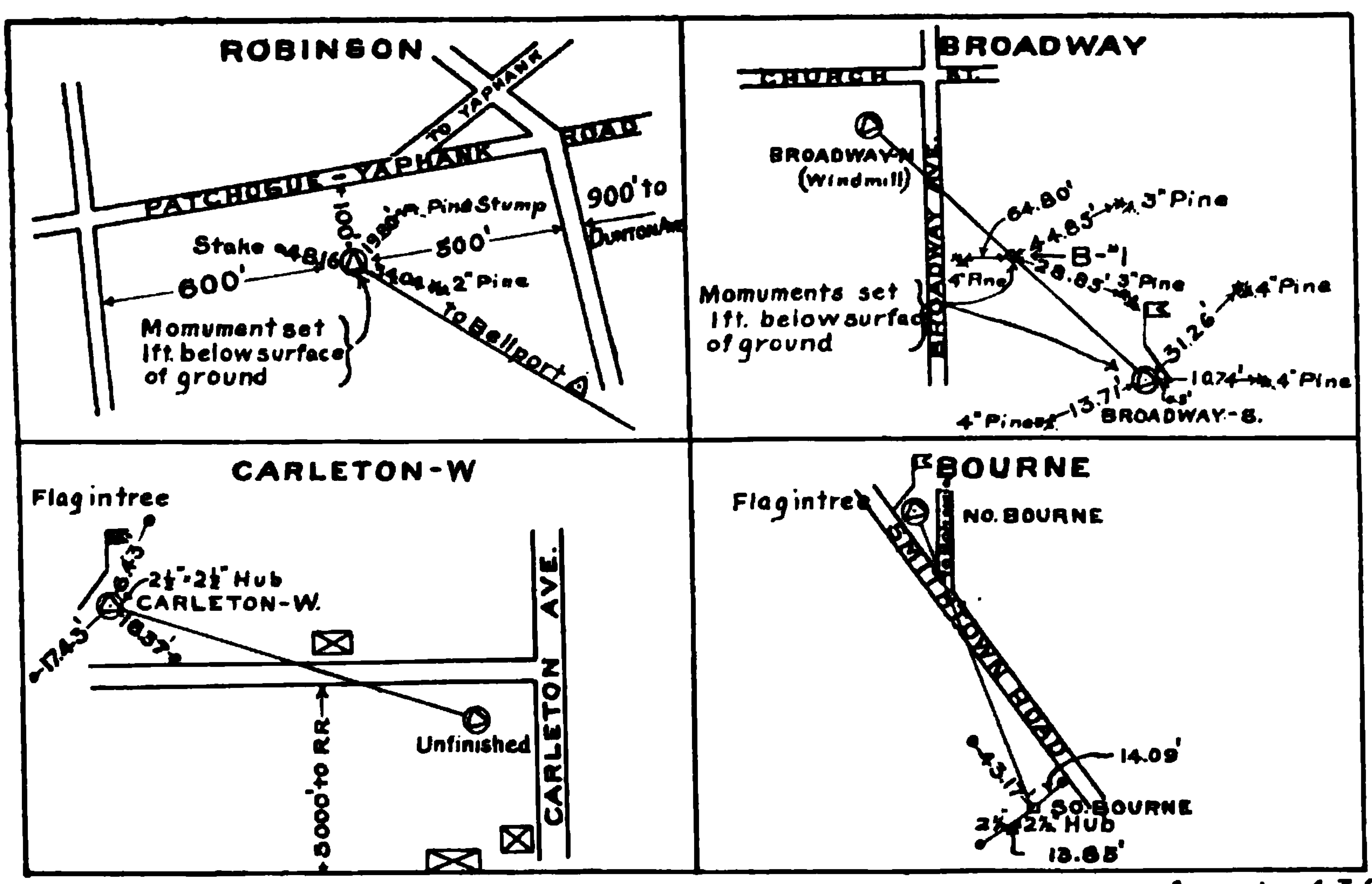
AZIMUTHSTAKES—PATCHOGUE SECTION



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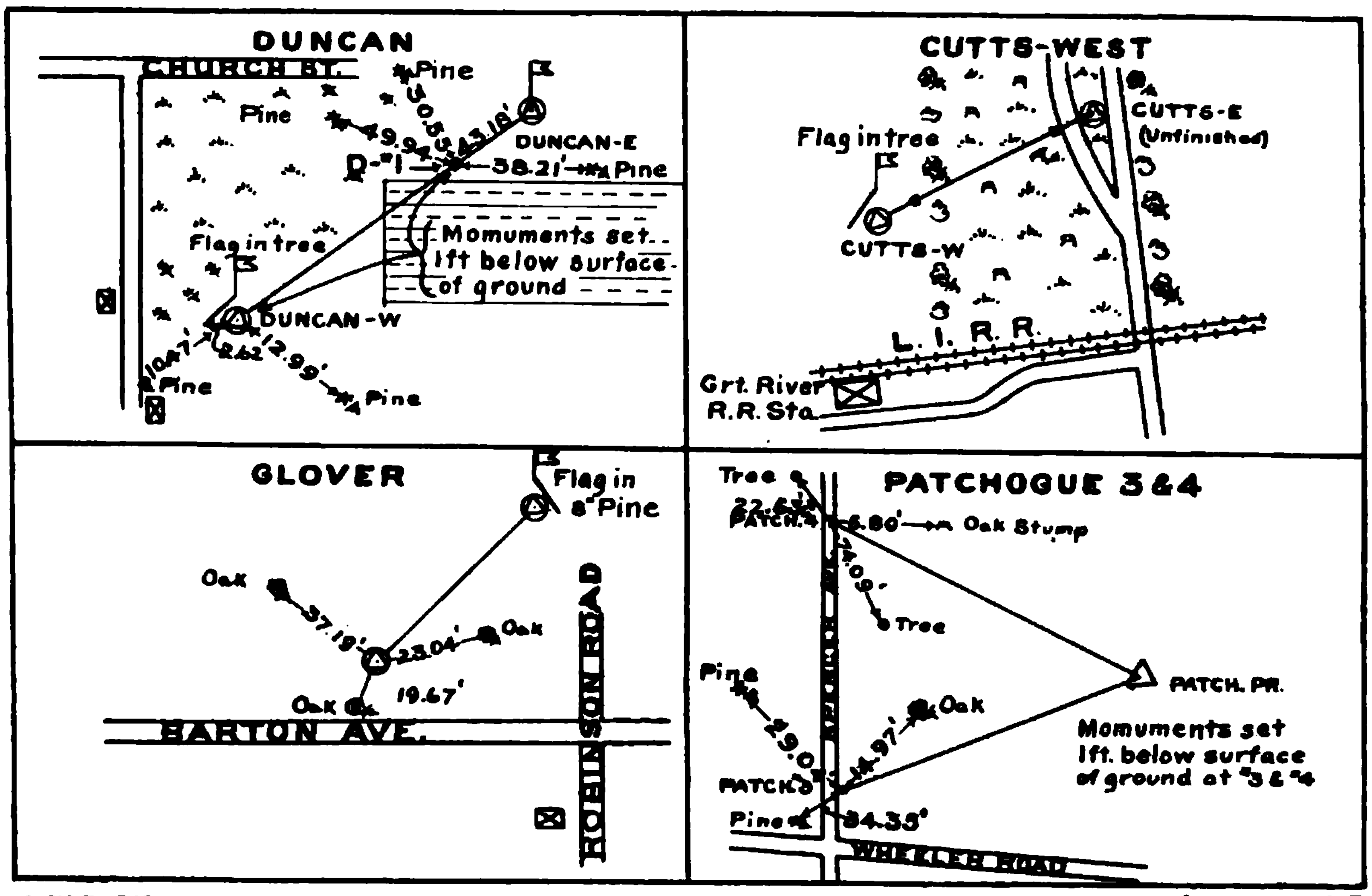
SHEET 163



AZIMUTH STAKES—PATCHOGUE SECTION

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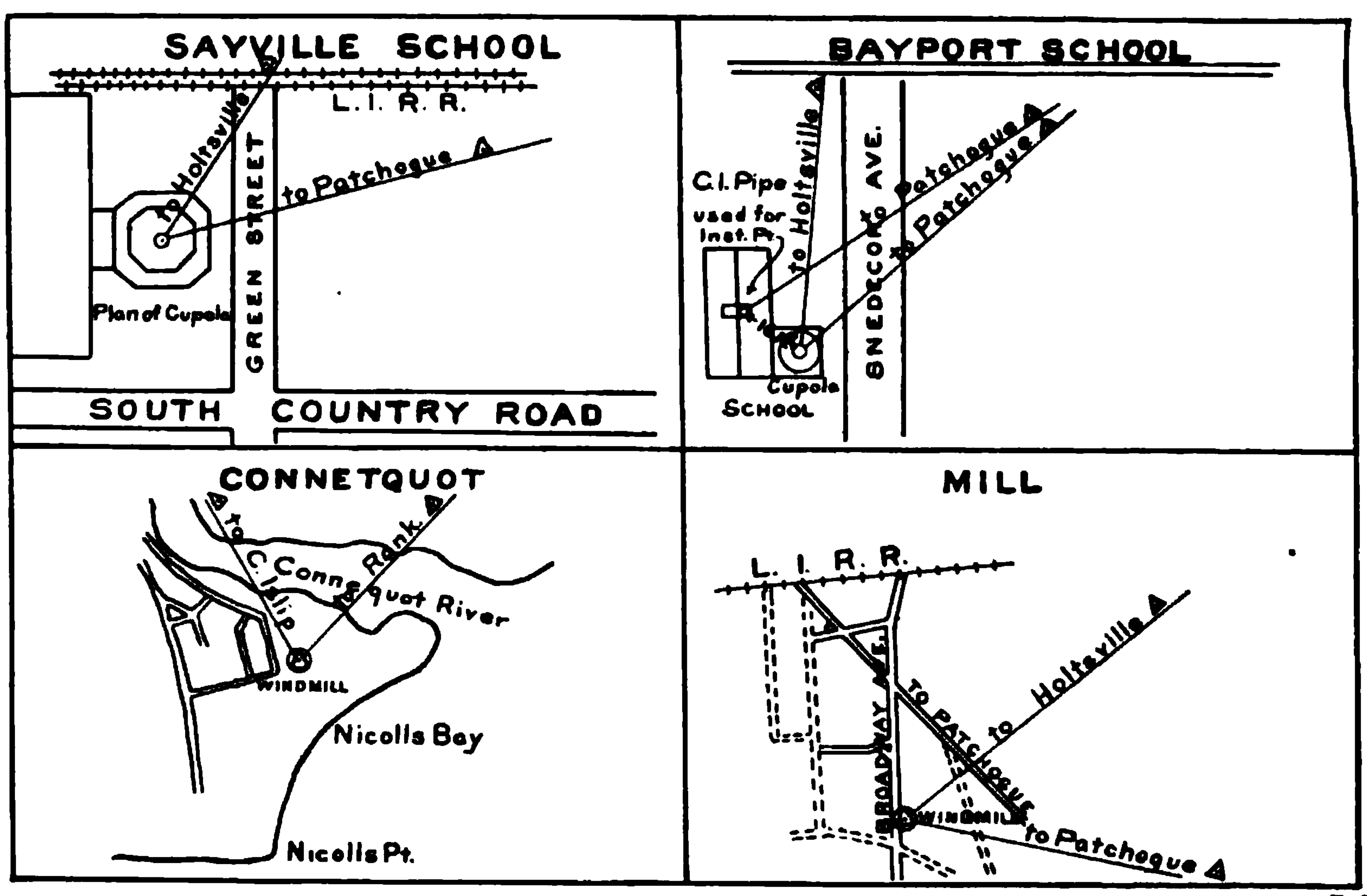

AZIMUTH STAKES—PATCHOGUE SECTION

B.W.S. 545

Acc. L-430

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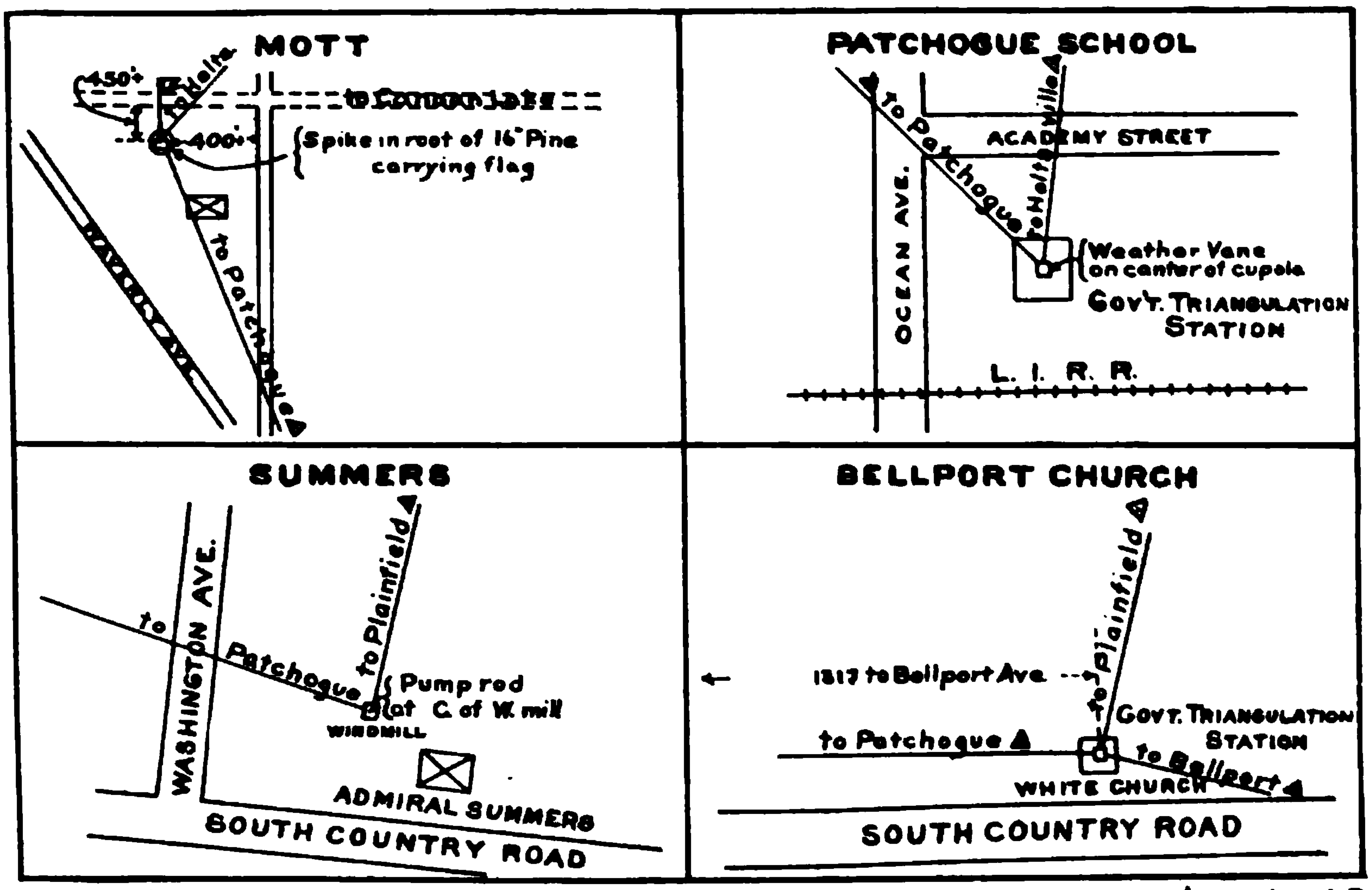

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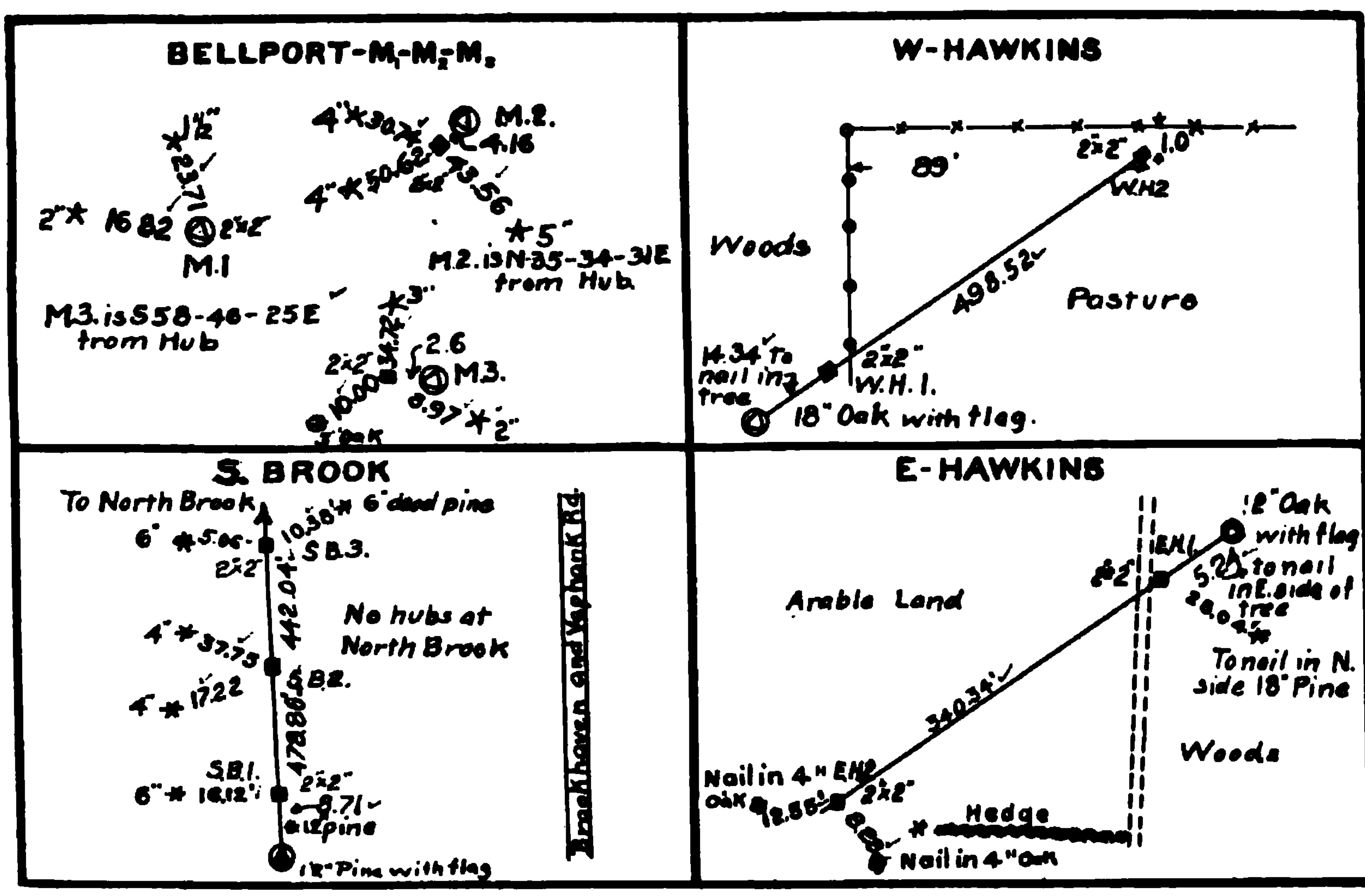
AZIMUTH STAKES—EASTPORT SECTION



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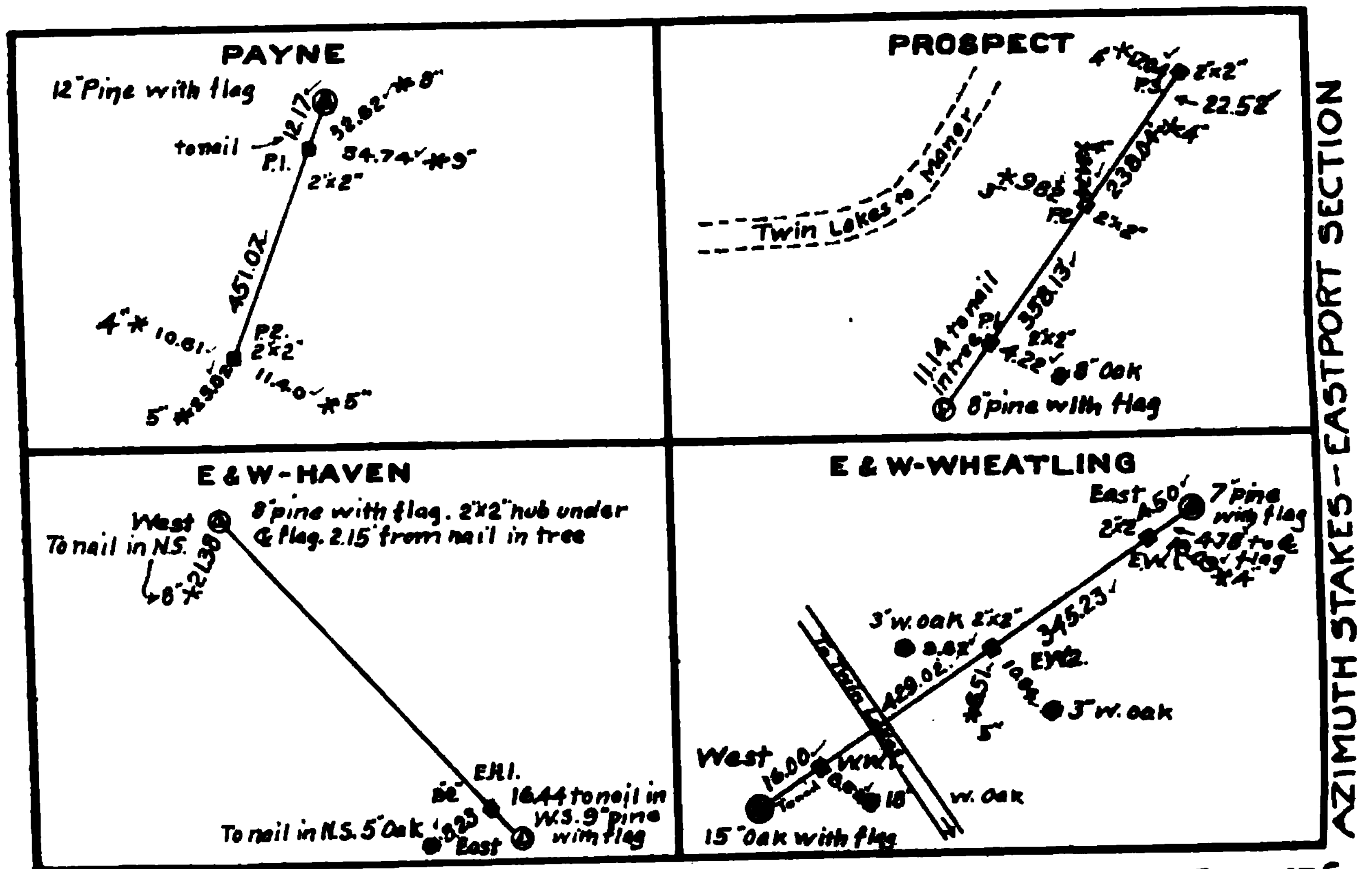
SHEET 165



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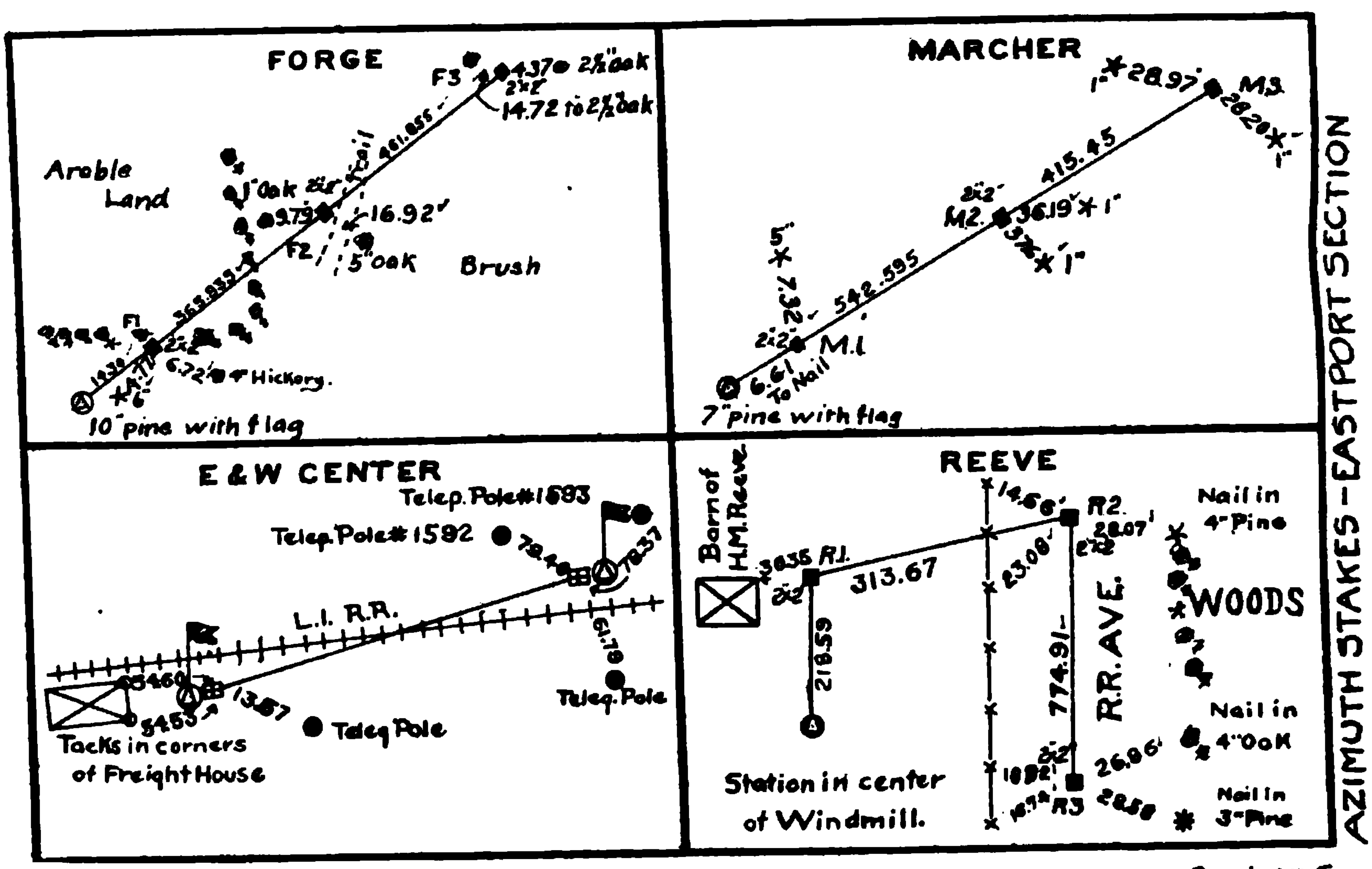

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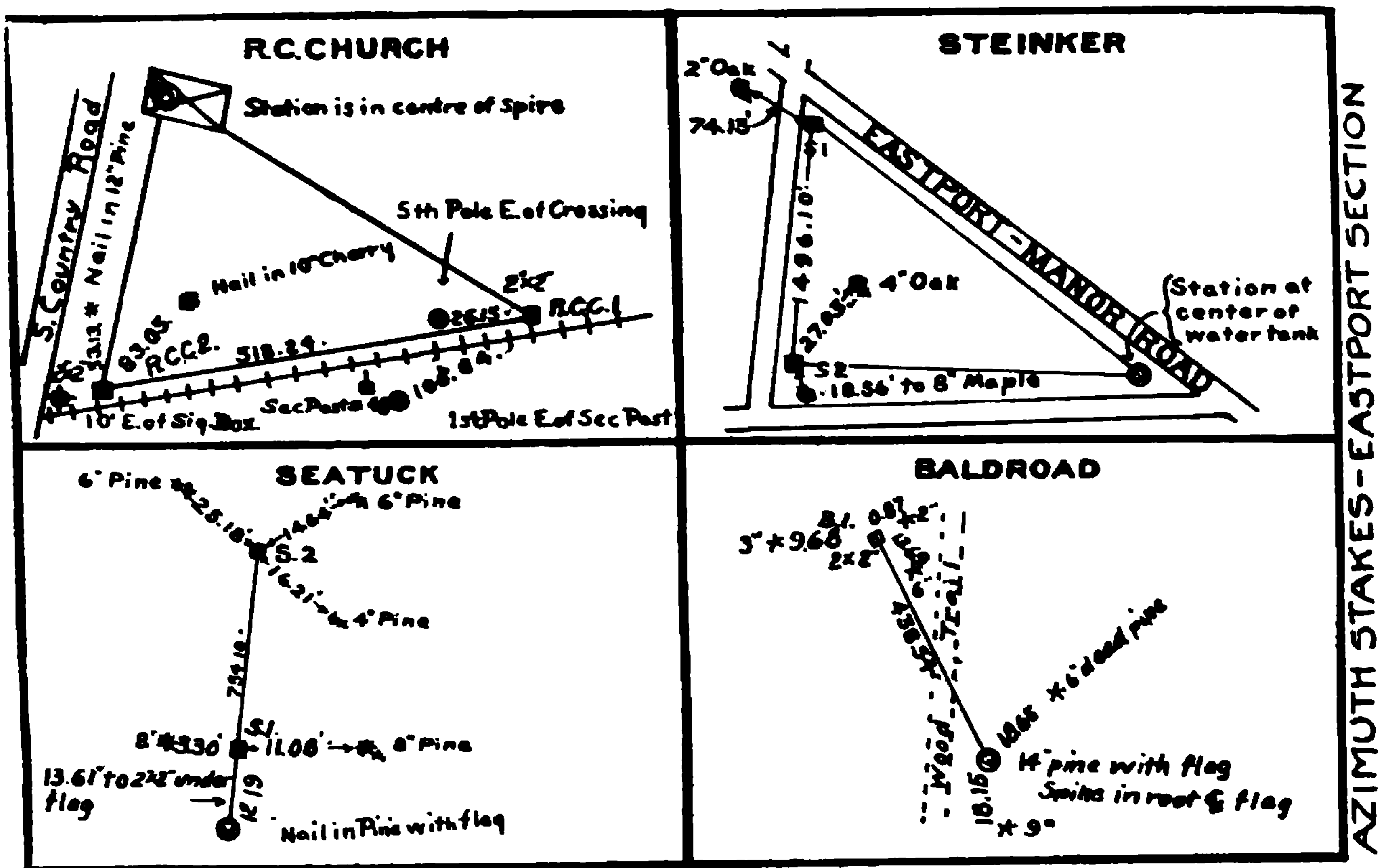

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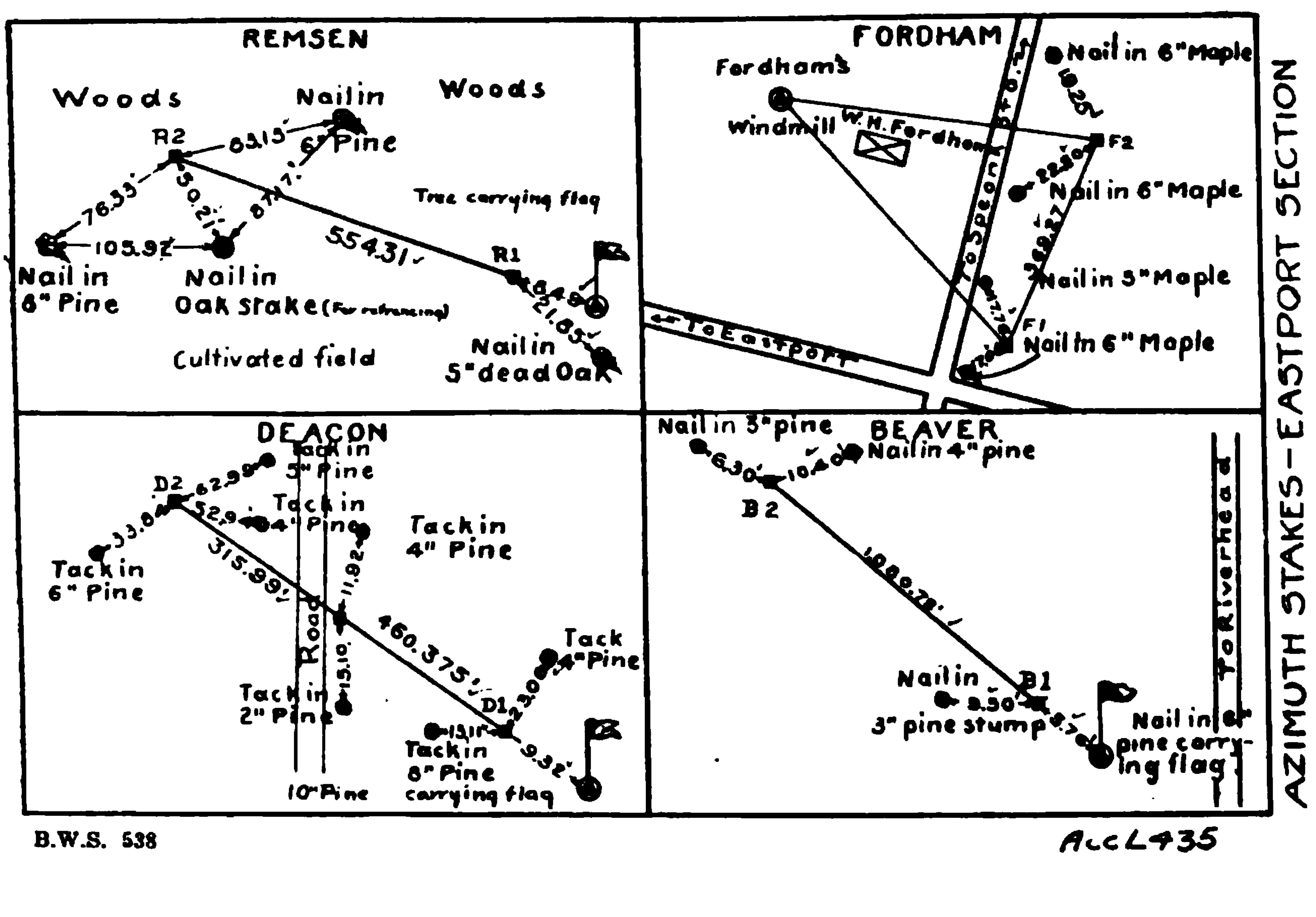

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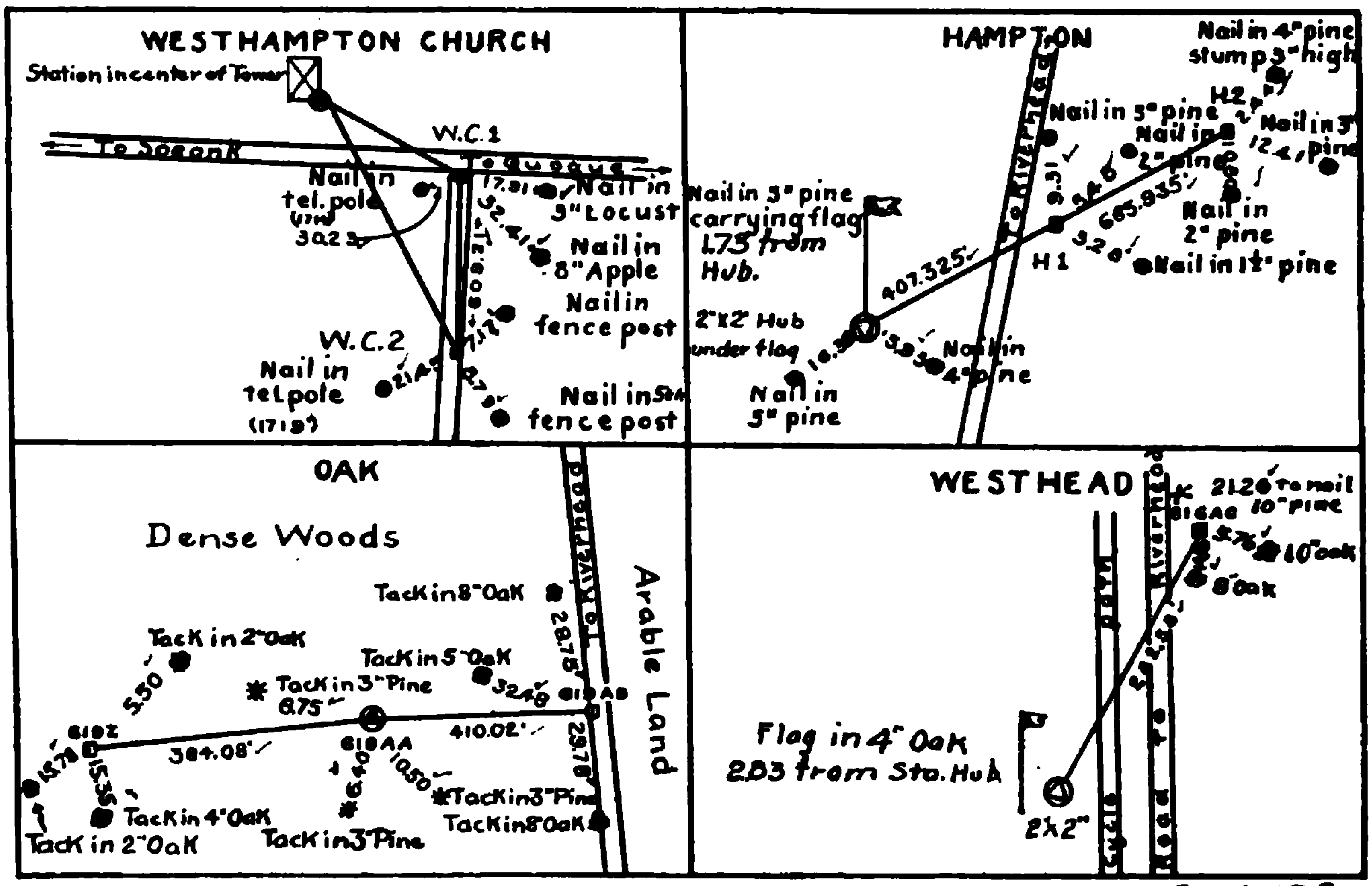
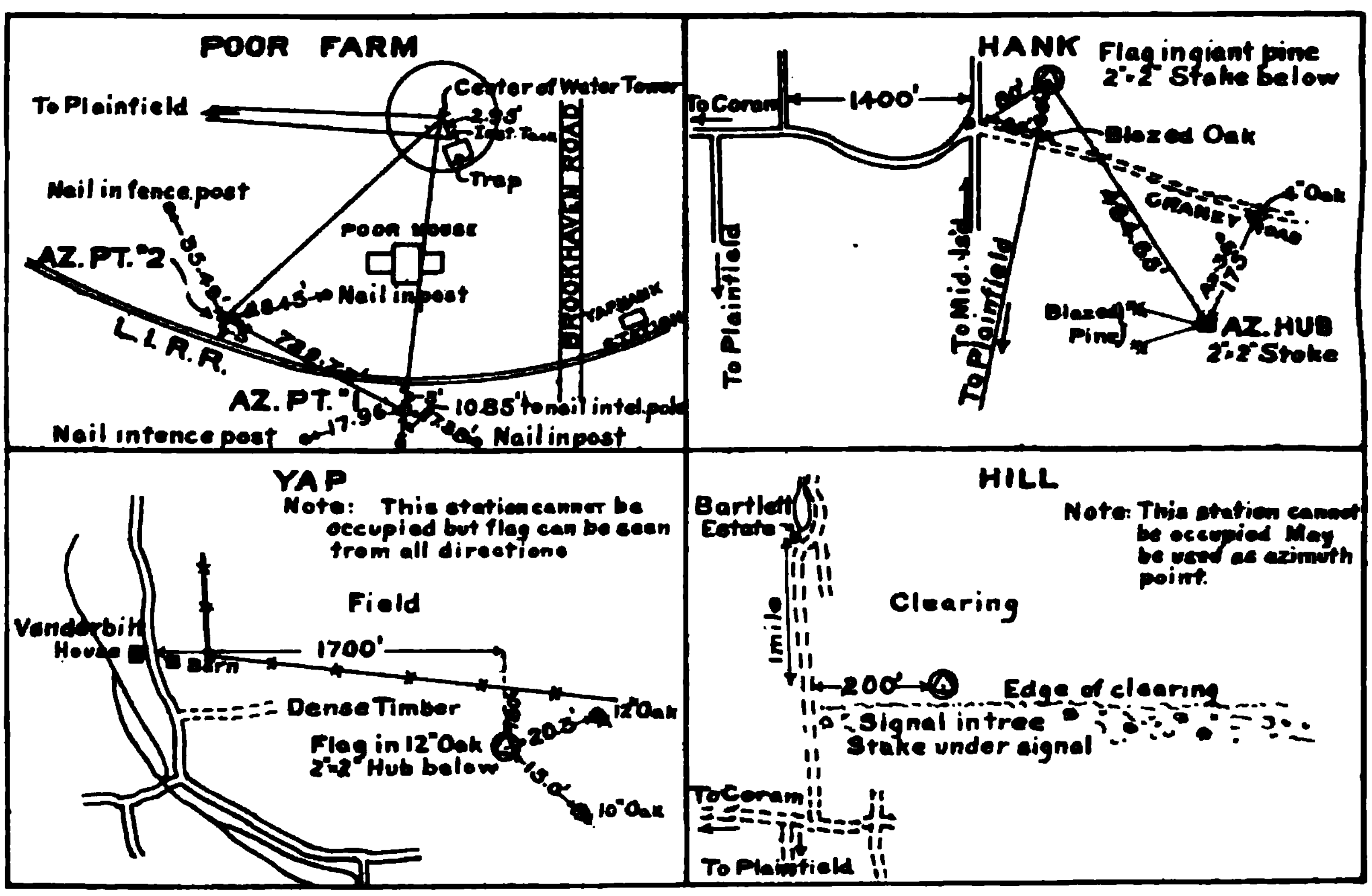


AZIMUTH STAKES—EASTPORT SECTION

B.W.S. 539

AccL435

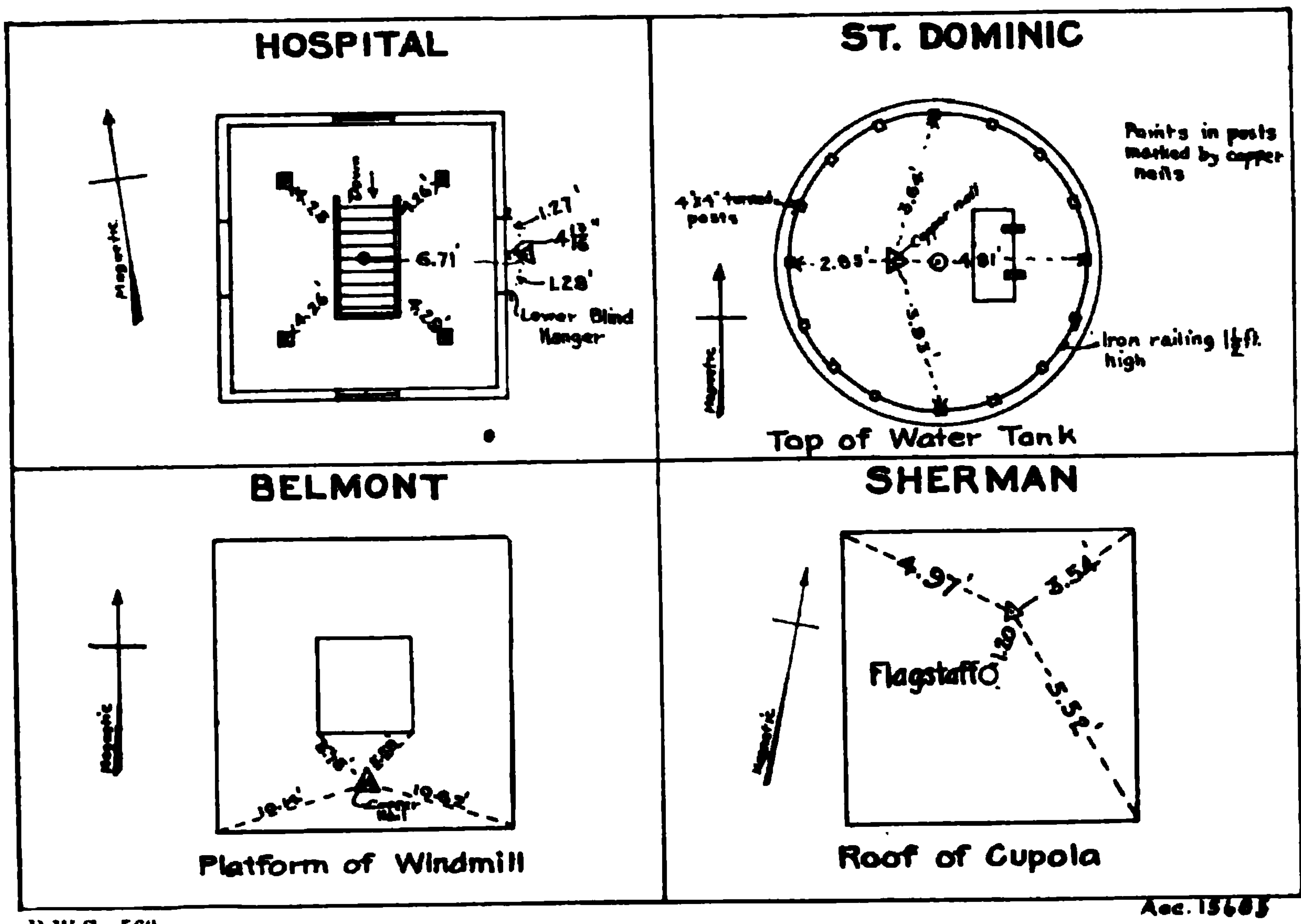


AZIMUTH STAKES—EASTPORT SECTION

B.W.S. 517

Acc. L 430

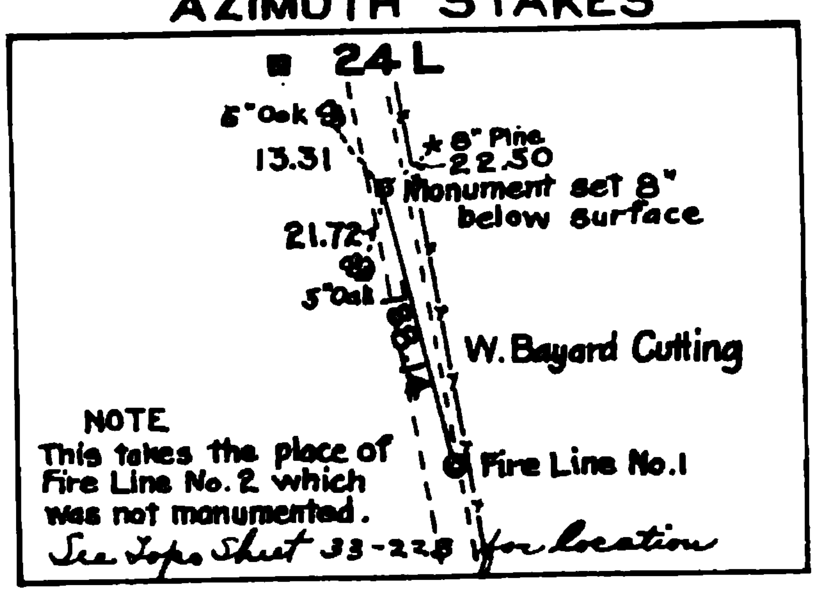
PRIMARY TRIANGULATION STATIONS TIES



B.W.S. 569

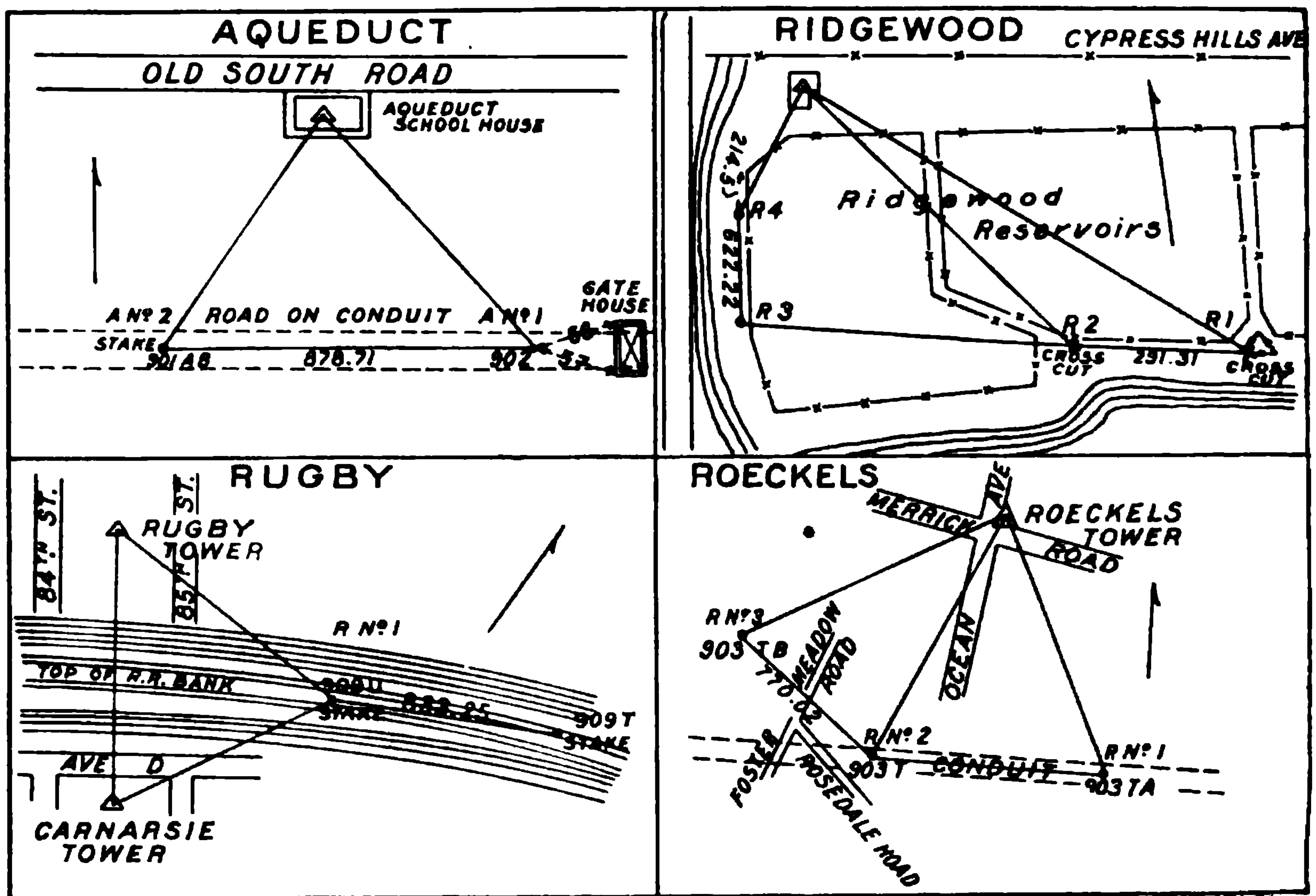
Acc. 13683

SECONDARY TRIANGULATION STATIONS
AZIMUTH STAKES

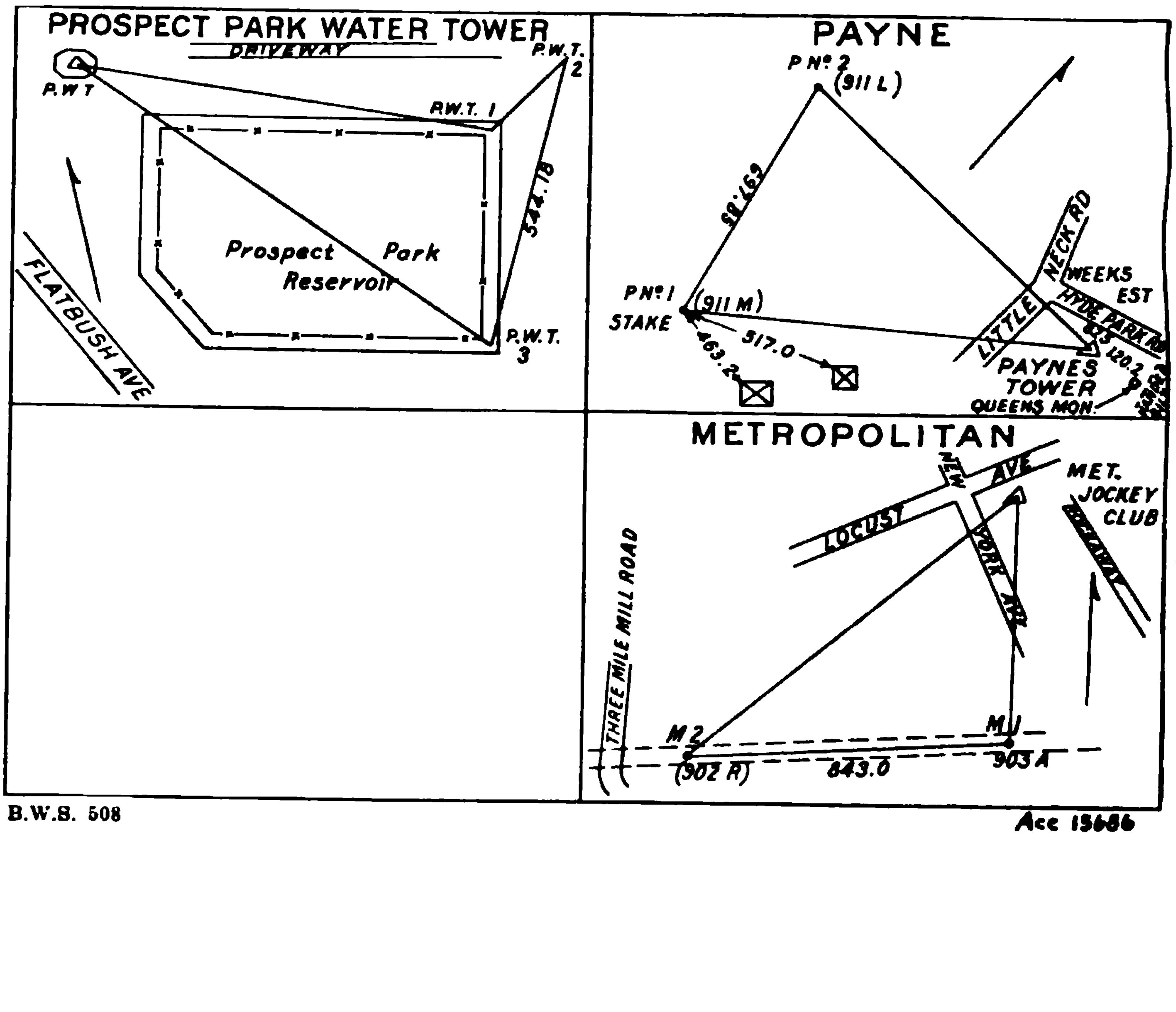


B.W.S. 570

SHEET 169



B.W.S. 507 Acc. 15686



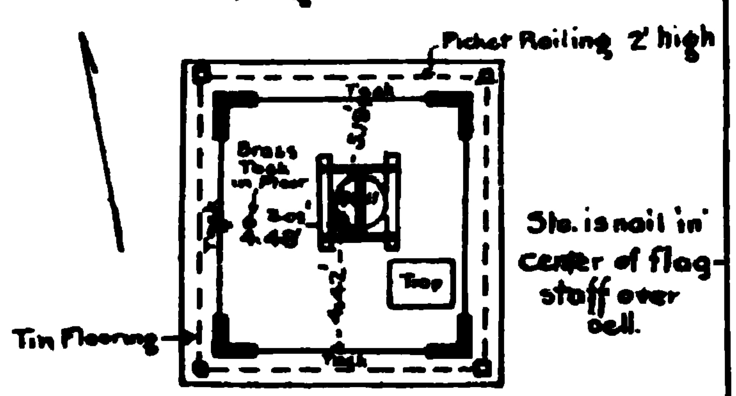
B.W.S. 508 Acc 15686

AZIMUTH STAKES
JAMAICA SECTION

AZIMUTH STAKES
JAMAICA SECTION

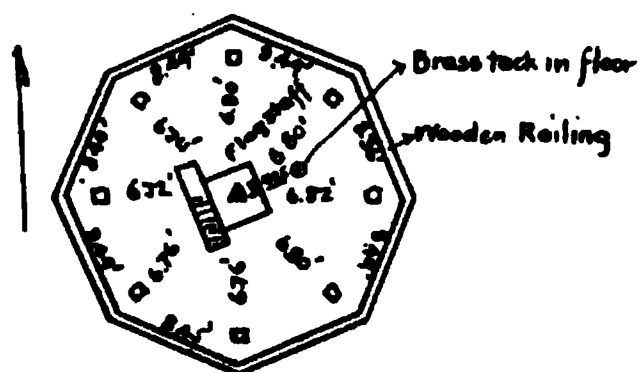
TRIANGULATION STATIONS TIES

AQUEDUCT.



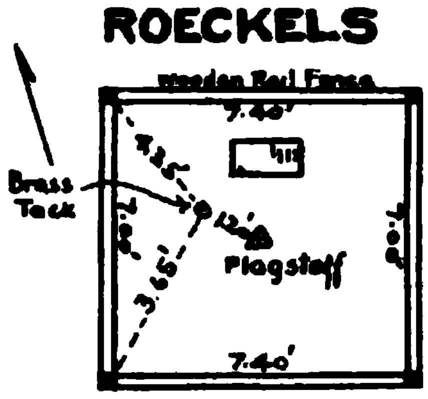
Bell Tower Floor

METROPOLITAN



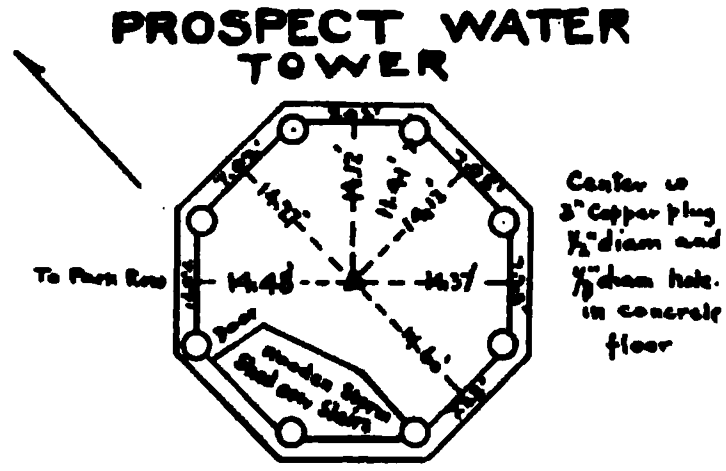
Observation Tower Floor.

ROECKELS



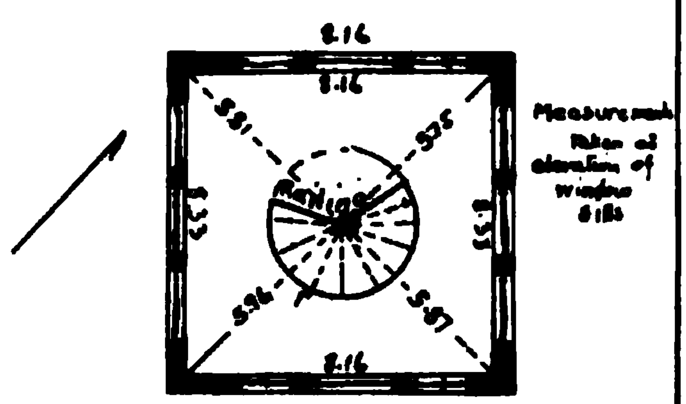
ACC 15687 Cupola Floor

PROSPECT WATER TOWER



B.W.S. 547

RIDGEWOOD



Top Floor of Tower

TABLE 52

STATION From	STATION To	AZIMUTH	DISTANCE	ELEVATION	COORDINATES	(11)
HOSPITAL △	H.1	136-38-30.3	256.38		N. 4 905.896 E. 150 964.724	
H.1	H.2	7-54-50.0	631.14	28.60	N. 4 719.49 E. 151 140.74	
H.2	△	210-56-00.0	511.47	31.20	N. 5 344.62 E. 151 227.64	
H.1	11 A	276-27-00.0	879.07		N. 4 818.3 E 150 267.2	
ST. DOMINIC △	D.1	226-07-22.4	977.23		N. 12 243.660 E. 156 399.455	
D.1	D.2	26 21-42.4	895.92		N. 11 566.33 E. 155 695.05	
D.2	△	112-14-52.4	331.26		N. 12 369.08 E. 156 092.86	
WELLWOOD △	W.1	94-24-59.1	368.49		N. 1 579.393 E. 164 873.977	
W.1	W.2	345-56-29.0	546.36		N. 1 551.01 E. 165 241.38	
W.2	△	205-04-19.0	553.80		N. 2 081.01 E. 165 108.67	

PRIMARY TRIANGULATION STATIONS
AZIMUTH STAKES

B.W.S. 431

STATION From	STATION To	AZIMUTH	DISTANCE	ELEVATION	COORDINATES	(12)
VULCANITE △	V.1	302-29-28.7	396.39		N. 5 910.196 E. 165 782.178	
V.1	V.2	67-01-19.0	613.90		N. 6 123.13 E. 165 447.84	
V.2	△	207-01-29.0	508.06		N. 6 362.79 E. 166 013.03	
BELMONT △	B.1	229-46-30.7	786.33		N. 21 048.060 E. 172 797.985	
B.1	B.2	6-55-51.3	680.73		N. 20 540.36 E. 172 197.60	
B.2	△	107-57-23.6	544.77		N. 21 216.11 E. 172 279.75	
SHERMAN △	S.1	277-25-26.0	180.20		N. 9 420.438 E. 178 687.672	
S.1	S.2	73-39-26.0	344.75		N. 9 443.72 E. 178 508.98	
S.2	△	231-39-56.0	193.94		N. 9 540.73 E. 178 839.80	

PRIMARY TRIANGULATION STATIONS
AZIMUTH STAKES

B.W.S. 432

TABLE 52 (*Concluded*)

PRIMARY TRIANGULATION STATIONS
AZIMUTH STAKES

STATION From	STATION To	AZIMUTH	DISTANCE	ELEVATION	COORDINATES	13
KEITH Δ	K.1	177-10-53.2	332.36		N. 27 348.248 E. 187 929.628	
K.1	K.2	342-18-49.8	605.64		N. 27 016.29 E. 187 945.97	
K 2	Δ	81-09-21.7	296.32		N. 27 593.31 E. 187 761.98	
~~K.3~~	~~Δ~~	161-49-16.0				
BOSSERT Δ	BT. 1	331-15-12.2	3 463.08		N. 14 146.993 E. 193 834.207	
BT. 1	BT. 2	246-09-02.1	849.46		N. 17 183.26 E. 192 168.69	
BT. 2	Δ	165-16-09.5	3494.60		N. 17 526.73 E. 192 945.62	
ISLIP Δ	I. 1	62-27-31.4	484.52		N. 23 668.908 E. 209 082.488	
I. 1	I. 2	152-37-27.4	438.18		N. 23 892.95 E. 209 512.11	
I. 2	Δ	284-39-28.2	652.33		N. 23 503.84 E. 209 713.59	

B.W.S. 424

PRIMARY TRIANGULATION STATIONS
AZIMUTH STAKES

STATION From	STATION To	AZIMUTH	DISTANCE	ELEVATION	COORDINATES	14
CENTRAL ISLIP Δ	C.I. 1	166-12-12.6	5 755.37		N. 42 526.178 E. 212 285.131	
C.I. 1	C.I. 2	292-05-47.6	587.00		N. 36 838.16 E. 213 163.06	
C.I. 2	Δ	351-13-32.6	5 432.08		N. 37 250.81 E. 213 580.53	
~~Δ~~	~~C.I. 3~~	196-48-02.0	195.00		N. 42 526.178 E. 212 285.131	
C.I. 3	C.I. 4	351-26-49.5	361.45		N. 42 339.50 E. 212 228.77	
C.I. 4	Δ	147-10-58.7	203.18		N. 42 696.93 E. 212 175.02	
EAST BASE	TO VULCANITE	195-34-08.1			N. 11607.29 E. 167369.50 N. 3910.20 E. 165782.18	
	TO ST. DOMINIC	273-19-12.1			N. 12243.66 E. 156399.46	
WEST BASE	TO VULCANITE	154-00-28.7			N. 14375.28 E. 161654.93 N. 3910.20 E. 165782.18	
	TO ST. DOMINIC	247-55-21.1			N. 12243.66 E. 156399.46	

B.W.S. 440

TABLE 53

Station From	Station To	AZIMUTH	DISTANCE	ELEVATION	COORDINATES	(15)
SLENDER ⊙	Sl. 1	310-01-46.3	265.60		N. 11560.03 E. 149994.41	
Sl. 1	Sl. 2	172-04-32.9	381.10		N. 11789.31 E.149721.46	
Sl. 2	⊙	36-05-16.3	356.48		N. 11411.85 E.149774.00	
MONAHAN ⊙	M. 1	42-06-26.9	151.53		N. 8168.06 E.152715.89	
M.1	M.2	281-00-45.3	224.12	36.08	N. 8280.48 E.152817.49	
M.2	⊙	322-40-10.3	195.22	36.91	N. 8323.29 E.152597.51	
COPAIGUE				29.03	N. 4716.46 E.155847.05	
RED HOUSE ⊙	R.H.1	147-27-15.0	2040.74		N. 5927.89 E.159525.91	
R.H.1	R.H.2	248-33-55.0	717.46		N. 4207.62 E.160623.78	
R.H.2	⊙	347-45-40.0	2028.56		N. 3945.43 E.159956.95	

SECONDARY TRIANGULATION STATIONS
AZIMUTH STAKES

B.W.S. 441

Station From	Station To	AZIMUTH	DISTANCE	ELEVATION	COORDINATES	(16)
LINDENHURST ROAD		281-19-36.6	ST. DOMINIC	39.30	N. 11226.49 E. 161 477.53	
GREEN HOUSE ⊙	G.H.1	137-49-10.0	222.90		N. 14 029.25 E 169.425.90	
G.H.1	G.H.2	292-14-00.0	431.07	34.91	N. 13.864.07 E.169 575.57	
G.H.2	⊙	89-31-30.0	249.36	33.60	N. 14 027.18 E.169.176.55	
ANDERSON ⊙	A.1	54-28-56.5	311.86		N. 7 406.75 E.172 265.62	
A.1	A.2	166-54-06.5	373.27		N. 7 587.92 E.172 519.45	
A.2	⊙	298-19-16.5	384.44		N. 7 224.36 E.172 604.04	
BLATCHFORD ⊙	Bl.1	168-05-38.0	224.59		N. 12 585.00 E.172 627.67	
Bl.1	Bl.2	322-08-38.0	407.04	25.09	N. 12365.19 E.172674.01	
Bl.2	⊙	116-32-28.0	227.43	25.32	N. 12686.57 E.172424.21	

SECONDARY TRIANGULATION STATIONS
AZIMUTH STAKES

B.W.S. 442

TABLE 53 (*Concluded*)

STATION From	STATION To	AZIMUTH	DISTANCE	ELEVATION	COORDINATES	(17)
COCKERILL ●	C.1	226-53-14.8	741.22		N. 16 945.96 E.179 441.91	
C.1	C.2	346-18-31.8	548.46	27.66	N. 16439.37 E.178900.78	
C2	●	92-14-41.5	671.43		N. 1697226 E.178770.99	
HOUSMAN ●	Ho.1	237-32-57.1	615.41		N. 23 590.30 E.179 801.23	
Ho.1	Ho.2	5-20-27.1	324.68		N. 23 260.09 E.179 281.91	
Ho.2	●	89-11-12.1	489.14		N. 23 583.36 E.179 312.14	
●	H.3	79-23-21.1	4942.77		N. 23 590.30 E.179 801.23	
Ho.3	Ho.4	201-08-31.1	528.99		N. 24 500.45 E.184 659.48	
Ho.4	●	264-53-51.1	4686.03		N. 24 007.07 E. 184 468.69	
PADDLE					N. 29 494.49 E.180 549.38	

SECONDARY TRIANGULATION STATIONS
AZIMUTH STAKES

B.W.S. 481

STATION From	STATION To	AZIMUTH	DISTANCE	ELEVATION	COORDINATES	(18)
SAMMIS To HIGBIE		22-04-28.8	512.36	38.75 40.02	N. 20 318 .13 E.185 276 .48 N. 20 790 .90 E.185 469 .03	
HORN				25.35	N. 14 833.15 E.186 706.27	
THOMPSON					N. 25 190.36 E.190 484.18	
HYDE				39.97	N. 21 859.78 E 191 688.47	
ELECTRIC STACK					N. 20 916.60 E. 195 855.32	
ST. JOSEPH					N. 37835.27 E.201107.06	
RACE ●	R1	207-14-12.8	1001.68		N. 25 537.52 E.202 382.92	
R1	R2	349-40-41.9	1129.69	30.24	N. 24 646.96 E.201 924.49	
R.2	●	108-28-04.6	696.71	35.20	N. 25 758.22 E.201 722.09	
OROWOC				36.61	N. 30 328.84 E.205 329.28	
RED HOUSE ●	R.H.3	329-52-05	2079.89		N. 5 927.89 E.159 525.91	
R.H.3 (14 G)	R.H.4 (14 H)	76-20-45	723.78	34.80	N. 7 726.73 E.158 481.82	
R.H.4 (14 H)	●	170-11-05	1998.96	33.33	N. 7 897.59 E.159 185.17	

SECONDARY TRIANGULATION STATIONS
AZIMUTH STAKES

B.W.S. 482

TABLE 54

PRIMARY TRIANGULATION STATIONS - PATCHOGUE SECTION

LOCALITY.	STATION	CÖORDINATES	ELEVATION OF STAKE	DESCRIPTION OF B.M. (1)
COAL ELEVATOR WEST OF R.R.STA SOUTH OF TRACK	ISLIP	23,668 908 209,082 488	19.082	B.M. AZ STAKE #1 - CARLETON AVE SEE NOTES M'13
R.C.Ch. E SIDE CARLETON AVE 1/4 M. So. OF Sta	CENT. ISLIP	42,526 178 212,286.131	80 148	BOLT. IN ROOT OF MAPLE. E OF CARLETON AVE - 40' No. OF △ STA SEE NOTES APR 2
CUTTING'S W.M. E. OF GRT. RIV. N. OF. LIRR.	CUTTING	27,428 442 222,916 440	29.525	B.M: N.E COR.- NE FOUNDATION. SEE NOTES APR 15
F.G. BOURNE'S. W.M. NEAR OAKDALE	OAKDALE	21,538 058 237,047 616	19.082	AZ. STAKE #1 6 FT. N. OF LIRR 29' W. OF BOURNE ROAD. SEE NOTES MAY 3
C OF CUPOLA HOUSE N. OF, LIRR. AT CURVE 4000 FT. W. OF STA	RONKONKOMA	49,993 421 253,217 203	103.631	STAKE AT END OF BASE LINE B.M. 391. SEE NOTES APR. 2
LACE MILL. W. TANK. W. PART. OF PATCH	PATCHOGUE	35,767 297 261,088 366	14 327	B.M: BOLT. IN LADDER LEG. OF PATCHOGUE. TANK AT △ STA NOTES
B.W.S. TRIPOD TOWER 800' E. OF. RR. STA	HOLTSVILLE	52,817 897 256,320 493	106835	B.M: AZ STAKE UNDER TOWER SEE NOTES APR 2
LANGLEY'S. WIND MILL BELLPORT	BELLPORT	34,247.125 287,171 254	31 72	GROUND UNDER TOWER SEE NOTES MAY 15
4 M. N. OF B'PORT W TANK. LIRR AGT. EXP. STA	PLAINF'LD	55.889 584 277,122 638	106 829	B.M: S.W. COR. OF CONCRETE FOUNDATION OF TOWER SEE NOTES. MAY 15.
			NOTE: ALL ELEVATIONS REF'D TO B.W.S. DATUM	

B.W.S. 394

TABLE 55

SECONDARY TRIANGULATION STATIONS - PATCHOGUE SECTION (1)

LOCALITY	STATION	COORDINATES	ELEVATION OF STAKE	AZIMUTH	DESCRIPTION
SAYVILLE.	SAYVILLE SCHOOL	25021.81 244169.09	approx. 22.92 1 Block N of School		Center of cupola on School-house on Green Street, Sayville
BAYPORT.	BAYPORT SCHOOL	26,628.99 253,006.07	Approx 23.163 Bench on R.R.		Center of cupola of school-house on Snedecor Ave, Bayport
about one mile W. of Oakdale.	CONNETQUOT	18,202.71 227031.75			Pump rod of wind-mill. Wind-mill & tank similar to Cutting
About one mile NNW. of Patchogue.	MILL	45543.14 249197.91			Center of pump-rod on wind mill on B'way Ave. 3m. N. S.C. Rd.
about ¾ mile N. of Patchogue.	MOTT	42431.24 257477.40			Flag in tree near house of Mr Mott.
PATCHOGUE.	PATCHOGUE SCHOOL	34359.76. 264323.65	18.63 S. side of School	Note. All elevations B. W. S.	reduced to datum.
about one and one half miles W. of Bellport.	ROBINSON	40624.38 276185.86.			Monm't 1' in ground on rd from E. Patchogue to Yaphank about 1 M. N. of Dunton Av.
BELLPORT	BELLPORT Church.	33635.59 285690.02			Center of ball on steeple of white church on S.C. Rd in village of Bellport
about one and one half miles N. of Sayville.	DUNCAN W.	32807.02 243,306.54	48.457	52-58-59.3	Monm't 1' in ground about 150' E. of Moscow Ave & 1 M. N. of int of Moscow & Carleton Aves
About one and one half miles N of Sayville.	DUNCAN E.	33499.84. 244,225.38	47.698		Flag in pine tree 1000' E. of Moscow Ave & 1 M. N. of int. of Moscow & Carleton Ave.

B.W.S. 396

SECONDARY TRIANGULATION STATIONS - PATCHOGUE SECTION (2)

LOCALITY	STATION	CO-ORDINATES	ELEVATION OF STAKE	AZIMUTH	DESCRIPTION
about one mile NNW of Sayville.	BOURNE ⊙ W.	29420.61 239745.14	46 155	325-05-30	2½ x 2½ hub in ground on W side Smithtown Rd about 1 M. N. of R.R.
About one mile N. W. of Sayville	BOURNE Az. Pt. E.	31297.10. 238439.72	50.646.		Flag in pine tree at int. of Smithtown Rd & rd running N. to Bohemia
about one mile N. of Blue Point.	BROADWAY ⊙ W.	33031.72. 249,879.83	40 081	349-27-40.	Monument 1 ft. in ground about 200' E of Broadway Ave ½ M. N. of R.R.
About one mile N. of Blue Point	BROADWAY Az. Pt. E.	35962.14 249334.65			Note: All elevations reduced to B. W. S. datum
	CARLETON				
1¼ Mile N. of S.C. Rd. running thru W. Islip.	CARLETON Az. Pt.	30582.54 212 299.51			Flag in high pine tree 1000' W. of Carleton Ave. 1 M. N. of R.R.
About three quarters of a M. N. of Great River R.R. Sta.	CUTTS ⊙				Flag in 12" pine about 1000' W. of first trail or road E. of Gt. River Sta. running N. from S.C. Rd ¾ M. N. of R.R.
	CUTTS Az. Pt.	31735.69 217397.78.			
One mile N. of East Patchogue	GLOVER ⊙	44031.01 271,111.71	55 618	00-49-40	2½ x 2½ hub in ground about 250' N. of Barton Ave & 200' W. of Robinson's Road
One mile N. of East Patchogue.	GLOVER Az. Pt.	44844.56 27112346			1050' N. of Barton Ave. and 100' W. of Robinson's Road.

B.W.S. 397

TABLE 56

AZIMUTH STAKES PATCHOGUE SECTION

Station From	Station To	Azimuth	Distance	Elevation	Coordinates	Description (3)
Patchogue						
Δ	Pa. 1	329-38-29.4	3304.91	14.327	35767.297 261,688.366	Lace-Mill Water Tank West part of Patchogue
Pa. 2	Δ	219-11-42.7	3840.10	36.941	38,743.37 264,115.18	2½x2½ hub in ground at int. of Roe Ave. & Wayne St.
Pa 1	Pa. 2	88-15-42.7	4099.025	34.197	38,619.04 260,018.04	2½x2½ hub in ground at int. of Roe Ave & Waverly Ave.
Δ	Pa 3	261-57-18.5	6802.89	14.327	35767.297 261688.366	Lace-Mill Water Tank West part of Patchogue
Pa. 4	Δ	107-19-08.5	7125.80	51309	37888.59 254,885.64	2½x2½ hub in ground on Spencer Ave. about 5000' N of its int. with Wheeler Rd.
Pa. 3	Pa. 4	358-45-18.5	3074.07	44535	34,815.25 254,952.43	2½x2½ hub in ground on Spencer Ave. 4000' S of Patchogue # 4
Ronkonkoma						
Δ	Ro. 1	250-21-59.4	1189.85	103631	49993.421 233,217.203	Center of cupola of house N of L.I.R.R. at curve 4000' West of Sta.
Ro. 2	Δ	70-21-59.4	448.78	102130	49,842.66 232794.57	2½x2½ hub in ground on right of way of L.I.R.R. about [illegible] W. of Ronkonkoma # 1.
Ro. 1	Ro. 2	70-21-59.4	741.07	101.125	49,593.64 232,096.53	2½x2½ hub in ground on right of way of L.I.R.R. about [illegible] W. of Ronkonkoma Primary
		Note: All elevations reduced to N.Y.B.W.S. datum.				

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AZIMUTH STAKES PATCHOGUE SECTION

Station From	Station To	Azimuth	Distance	Elevation	Coordinates	Description (4)
Poor Farm						
⊙	P.F. 1	174 54 21.4	1174.11	54.02	58294.59 290098.67	Center of valve on water tank of County Poor Farm
P.F. 2	⊙	24 35 57.2	1460.67	52764	56966.49 289480.54	Mon. 1' in ground on R of W of L.I.R.R. 1300' W of Yaphank crossing and 3' N of track
P.F. 1	P.F. 2	257-36-44	729.73	50.919	57126.12 290202.82	Mon. 5' in ground on R of Way L.I.R.R. 600' W of Yaphank crossing and 3' S of track
Ronkonkoma						
Δ	Ro 4	83-01-46.2	1726.30		49,993.421 233217.203	
Ro 3	Δ	263-01-46.2	726.35		50,081.57 233,938.18	Monument 1ft in ground on line to Holtsville Δ
Ro. 4	Ro 3	263-01-46.2	999.95		50202.92 234930.74	do

B.W.S. 451

TABLE 57

AZIMUTH STAKES — EASTPORT SECTION

STATION From	STATION To	AZIMUTH	DISTANCE	ELEVATION	COORDINATES	DESCRIPTION (1)
BELLPORT						
△	BE	322-55-17.7	287.385		N34247.125 E287171.254	Center of Langley's Windmill. ½ M.E. of Bellport P.O.
BW	△	86-27-30.2	475.036		N34217.780 E286697.125	2X2 Oak hub. S. side S.C. Rd. near private entrance
BE	BW	229-19-02.7	396.742		N34476.404 E286997.988	2x2 Oak hub. So. side S.C. Rd. near bottom of slope
MASTIC						
△	M1	49-18-51.5	828.404		N48973.149 E306623.116	40' tower with 6x6 mon'mt. set under U.M.H. Mastic Sta. 400' S. of S.C. Rd.
M2	△	168-31-49	371.17		N49336.910 E306549.308	6x6 mon'mt. N side of S.C. Rd. and 200' N. of Wm. Brenman's house.
M1	M2	255-54-11.5	723.78		N49513.193 E307251.292	6x6 mon'mt. N. side of S.C. Rd. 40' S.W. of Henrietta Gordon house.
RAYNOR						
△	R1	33-03-11.5	4546.711		N64852.408 E315579.649	40' tower. 6x6 mon. set under on Prospect Hill. 3000' S. of E.E. Raynor's house
R4	△	170-16-39.3	3195.257		N68001.767 E315040.051	6x6 mon'mt. N. side Main St. Manor.
R1	R2	260-31-50.9	1359.274		N68663.299 E318059.504	6x6 mon'mt. N. Side Main St. 2275' from S.W. cor. of Methodist Manor.
R2	R3	250-43-55.7	588.518		N68439.675 E316718.751	6x6 mon'mt. N.S. of Main St. 50' E. of rd. to N. Manor.

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AZIMUTH STAKES — EASTPORT SECTION

STATION From	STATION To	AZIMUTH	DISTANCE	ELEVATION	COORDINATES	DESCRIPTION (2)
R3	R4	257-45-26.7	1149.283		N68245.473 E316163.198	6x6 mon'mt. S. side Main St. 30' W. of entrance to house Manor.
FARNESWORTH						
△	EC1	28-04-41.6	4362.23		N47407.90 E326688.74	Center of A.B. Farnsworth's Windmill Ocean Ave. Center Moriches L.I.
WC1	△	173-22-22.7	3125.67		N50512.69 E326328.03	6x6 mon. on N side of L.I.R.R. right of way 2700' E. of C.M. Sta.
EC1	WC1	252-52-09.7	2528.98		N51256.72 E328741.94	6x6 mon. on S. side of L.I.R.R. r. of w. 300' E. of C.M. Sta.
CONVENT						
△	C1	16-54-57.97	573.978		N50386.414 E338578.608	Center of largest water tank of E. Moriches Convent.
C2	△	306-12-50.57	652.257		N50001.058 E339104.859	6x6 mon. on E. side of rd. to beach opposite Convent
C1	C2	338-58-19.97	1001.17		N50935.557 E338745.619	6x6 mon. on E. side of rd. to beach.
WILKINSON						
△	W1	84-07-56.5	1672.993		N52552.546 E361566.566	Center of Windmill of Dr. A.N. Wilkinson Oneck.
W2	△	305-36-11.6	1664.193		N51583.705 E362919.668	6x6 mon. on E. side of rd. leading to W.H.R.R. Sta.
W1	W2	195-16-00.7	1181.57		N52723.577 E363230.794	6x6 mon. on E. side of same rd. as W2.

B.W.S. 393

TABLE 57 (*Continued*)

STATION From	To	AZIMUTH	DISTANCE	ELEVATION	COORDINATES	DESCRIPTION (3)
BALDROAD						
B.1	△	171-52-28.4	438.54		67,368.11 349,164.69	2×2 Oak Hub 50' west of trail Secondary marked by spike in root of tree.
SOUTH BROOK						
S.B.1	△	172-39-03.2	29.88		51,705.534 291,095.018	6×6 Con Mon.
S.B.2	△	172-39-03.2	508.74		52,180.460 291,033.765	2×2 Oak Hub
S.B.3	△	172-39-03.2	950.78		52,618.868 290,977.221	6×6 Con. Mon.
WEST HAWKINS						
W.H.1	△	197-08-01.3	17.92		45,500.889 292,353.606	2×2 Oak Hub
W.H.2	△	197-08-01.3	516.44		45,977.284 292,500.471	2×2 Oak Hub
EAST HAWKINS						
E.H.1	△	17-08-01.3	5.24		46,969.290 292,806.29	2×2 Oak Hub on property of Emma Hawkins
E.H.2	△	17-08-01.3	345.58		46,644.054 292,706.026	2×2 Oak Hub
PAYNE						
P.1	△	11-26-52.3	11.72	57.47	51,207.121 307,076.238	2×2 Oak Hub
P.2	△	11-26-52.3	462.79	56.33	50,765.025 306,986.711	2×2 Oak Hub

AZMUTH STAKES - EASTPORT SECTION

B.W.S. 465

STATION From	To	AZIMUTH	DISTANCE	ELEVATION	COORDINATES	DESCRIPTION (4)
EAST HAVEN						
E.H.1	△	132-29-40.1	18.86		58,055.297 306,015.249	2×2 Oak Hub
WEST WHEATLING						
W.W.1	△	247-05-35.2	16.80		53,195.142 313,892.259	2×2 Oak Hub on property of R.L. Davison
EAST WHEATLING						
E.W.1	△	67-05-35.2	4.78	38.01	53,496.505 314,605.443	2×2 Oak Hub
E.W.2	△	67-05-35.2	350.01	34.46	53,362.14 314,287.44	2×2 Oak Hub
PROSPECT						
P.1	△	182-55-37.1	11.77		56,962.238 315,176.226	2×2 Oak Hub
P.2	△	182-55-37.1	369.90		57,319.960 315,194.513	2×2 Oak Hub
P.3	△	182-55-37.1	607.94		57,557.630 315,206.668	2×2 Oak Hub
HALLOCK						
△	H.1	280-18-49.4	898.706		54,614.306 377,712.551	Center of A.B. Hallock's windmill
H.2	△	60-24-29.6	1067.91		54,086.952 376,783.929	6×6 Con. Mon. West side of St. near Main St.
H.1	H.2	183-41-39.1	689.69		54,775.208 376,828.367	6×6 Con Mon. West side of St. 700' south of Main St.

AZMUTH STAKES - EASTPORT SECTION

B.W.S. 466

TABLE 57 (*Continued*)

AZIMUTH STAKES—EASTPORT SECTION

Station From	Station To	Azimuth	Distance	Elevation	Coordinates	Description (5)
FORDHAM						
△	F1	161-51-46	392.46		N56503.916 E349234.732	Center of Windmill of W.H. Fordham Speonk.
F2	△	279-35-08.1	307.74		N56452.671 E349538.176	2x2 Oak hub in field 20' E. of rd. to Speonk Sta.
F1	F2	29-23-58.7	369.27		N56130.957 E349356.902	2x2 Oak hub in field 20' E. of rd. to Speonk Sta. 369' S of F2.
W.H. CHURCH						
△	WC1	109-47-16.11	696.308		N55298.291 E356988.906	Center of tower on Methodist Church Main St. W. Hampton
WC2	△	320-52-16.11	1088.165	24.14	N54454.171 E357675.611	2x2 Oak hub on E. side of rd to Oneck.
WC1	WC2	177-02-06.11	609.21		N55062.564 E357644.099	2x2 Oak hub at junction of Main St. & rd. to Oneck
SEATUCK						
S1	△	190-59-55.9	13.61		N64953.074 E345040.89	2x2 Oak hub on N. slope of hill. 700' W of rd.
S2	△	190-59-55.9	758.715		N65697.861 E345185.645	2x2 Oak hub
REMSEN						
R1	△	110-11-01.6	9.68	48.09	N60767.23 E350314.675	2x2 Oak hub in scrub, 20' E. of field.
R2	△	110-11-01.6	563.99		N60958.49 E349794.40	2x2 Oak hub N. edge of field

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AZIMUTH STAKES—EASTPORT SECTION

Station From	Station To	Azimuth	Distance	Elevation	Coordinates	Description (6)
DEACON						
D1	△	138-36-45.8	12.97		N66318.209 E358094.407	2x2 Oak hub
D2	△	138-36-45.8	473.345		N66663.609 E357790.032	2x2 Oak hub
D3	△	138-36-45.8	789.335		N66900.683 E357581.117	2x2 Oak hub
FORGE						
F1	△	214-45-54.5	14.30		N52011.287 E321193.294	2x2 Oak hub in woods. 20' S. of field.
F2	△	214-45-54.5	380.235		N52311.901 E321401.955	2x2 Oak hub. 5' W. of wood trail
F3	△	214-45-54.5	842.09		N52691.313 E321665.311	2x2 Oak hub
BEAVER						
B1	△	149-05-45.6	6.65	55.09	N61384.281 E357687.293	2x2 Oak hub S. of valley
B2	△	149-05-45.6	1080.78	48.60	N62311.58 E357132.12	2x2 Oak hub N. slope of valley
HAMPTON						
H1	△	218-56-19.01	407.325	59.26	N63753.465 E365609.919	2x2 Oak hub 20' E. of rd.
H2	△	218-56-19.01	1073.26		N64271.443 E366028.450	2x2 Oak hub on E. edge of hill.

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TABLE 57 (*Concluded*)

AZIMUTH STAKES—EASTPORT SECTION

STATION From	STATION To	AZIMUTH	DISTANCE	ELEVATION	COORDINATES	DESCRIPTION (7)
MARCHER						
M1	◬	213-52-41.8	749		N56155.018 E324327.36	2x2 Oak hub
M2	◬	213-52-41.8	550.085		N56605.49 E324577.75	2x2 Oak hub
M3	◬	213-52-41.8	965.535		N56950.41 E324861.40	2x2 Oak hub
REEVE						
◬	R1	357-53-54.2	218.59		N57602.780 E332319.288	Center of Windmill of H.M. Reeve East Moriches
R1	R2	43-32-24.2	313.67		N57821.223 E332311.272	2x2 Oak hub 35' from barn & on line with N. end
R2	R3	174-33-09.2	774.91		N58048.600 E332527.347 N57277.190 E332600.911	(R2) 2x2 Oak hub on N side of rd (R3) 2x2 Oak hub
WEST CENTER						
WC1	◬	252-52-09.7	2.17		N50512.69 E326328.03	See Farnsworth △
E CENTER						
EC1	◬	72-52-09.7	3.22		N51256.72 E328741.94	do
R.C. CHURCH						
◬	RCC1	141-46-43.1	506.88		N53622.030 E335078.734	Center of spire R.C. Church East Moriches.
RCC2	◬	12-26-33.3	660.23		N52977.310 E334936.481	2x2 hub N. side L.I.R.R. r. of w.
RCC1	RCC2	241-35-54.5	518.24		N53223.809 E335392.343	2x2 Oak hub N. side L.I.R.R. r. of w.
STEINKER						
◬	S1	329-06-30.2	1227.292		N61329.644 E339093.123	Center of Chas. Steinkers Water Tank Tower, Eastport
S2	◬	82-50-19.14	1481.83		N61144.913 E337622.851	2x2 Oak hub E. side of rd. 50' N. of E. & W. road.
S1	S2	214-09-51.3	1496.10		N62382.832 E338463.011	2x2 Oak hub near Junc. of Manor & Riverhead Rds.

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TABLE 58

AZIMUTH STAKES
JAMAICA SECTION

STATION From	STATION To	AZIMUTH	DISTANCE	ELEVATION	COORDINATES	
PROSPECT W.T. ⊙	P.W.T1	108-11-39	477.12		N 0000 E 0000	
P.W.T.1	P.W.T.2	98-03-20	278.35	204.40	S 149.0 E 453.3	P.W.T. 1 = 910 A
P.W.T.2	P.W.T.3	227-42-14	544.18	205.52	S 188.0 E 728.9	P.W.T. 2 = 910 B
P.W.T.3	⊙	329-30-26	643.15	204.69	S 554.2 E 326.4	P.W.T.3 = 910C
RIDGEWOOD ⊙	R 1	129-39-43	1661.17		N 6656.31 E 21633.16	
R 1	R 2	266-48-51	291.38		N 5596.1 E 22912.0	R 1 = Base A
R 2	⊙	317-17-19	1461.3		N 7647.5 E 20559.5	R 2 = Base B
AQUEDUCT ⊙	A 1	111-50-53	522.89		S 2306.50 E 38556.67	
A 1	A 2	274-06-58	878.71	14.50	S 2501.09 E 39042.00	A 1 = 902
A 2	⊙	71-24-59	412.88		S 2438.0 E 38165.3	A 2 = 901 AB

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AZIMUTH STAKES
JAMAICA SECTION

STATION From	STATION To	AZIMUTH	DISTANCE	ELEVATION	COORDINATES	
METROPOLITAN ⊙	M 1	201-05-35	4571.84		N 2395.19 E 52875.05	
M 1	M 2	265-29-09	843.94	16.93	S 1870.3 E 51229.8	M 1 = 903 A
M 2	⊙	29-51-02	4996.23	17.20	S 1938.2 E 50388.2	M 2 = 902 R
HOLLIS					N 18336.51 E 55981.42	
ROECKELS ⊙	R 1	208-26-52	3346.3		N 790.99 E 66452.98	
R 1	R 2	272-44-06	357.64		S 3733.2 E 68047.0	R 1 = 903 TA
R 2	⊙	33-42-23	3516.3	30.60	S 2134.2 E 64501.7	R 2 = 903 T
CANARSIE ⊙	C 1	340-05-43	9028.4		S 15038.25 E 21002.63	
C 1	⊙	160-05-43	9028.4		S 6549.4 E 17928.9	C 1 = 909 U
PAYNE ⊙	P1	256-04-08	2962.8		N 31170.1 E 687553	
P1	P2	348-59-44	697.8	237.60	N 30456.8 E 65879.7	P1 = □ 911 M
P2	⊙	89-27-40	3008.9	226.22	N 31141.8 E 65746.5	P2 = □ 911 L
RUGBY ⊙	R1	50-04-43	5391.8		S 10009.5 E 13793.8	
R1	⊙	230-04-43	5391.8		S 6549.4 E 17928.9	R1 = □ 909U

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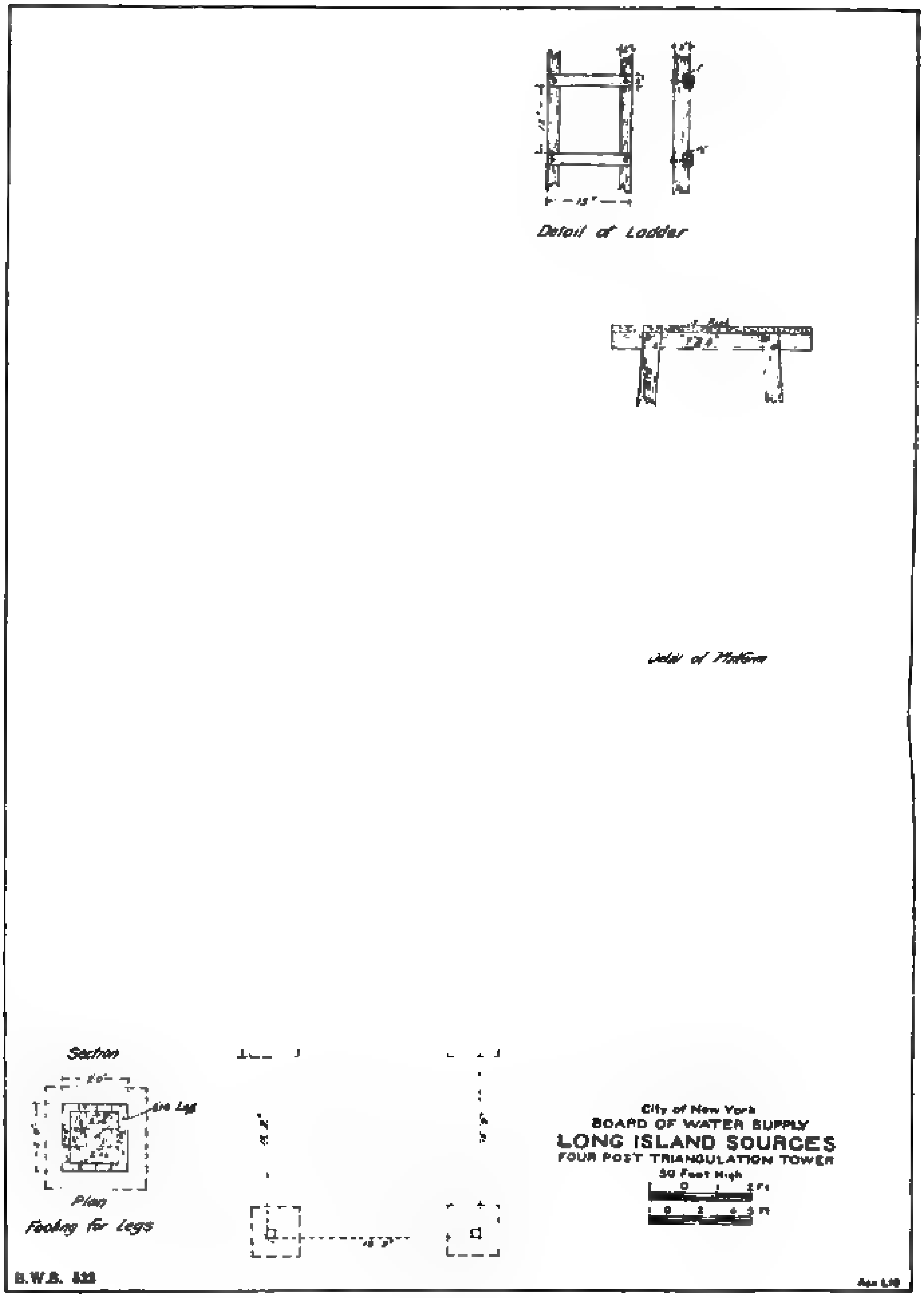
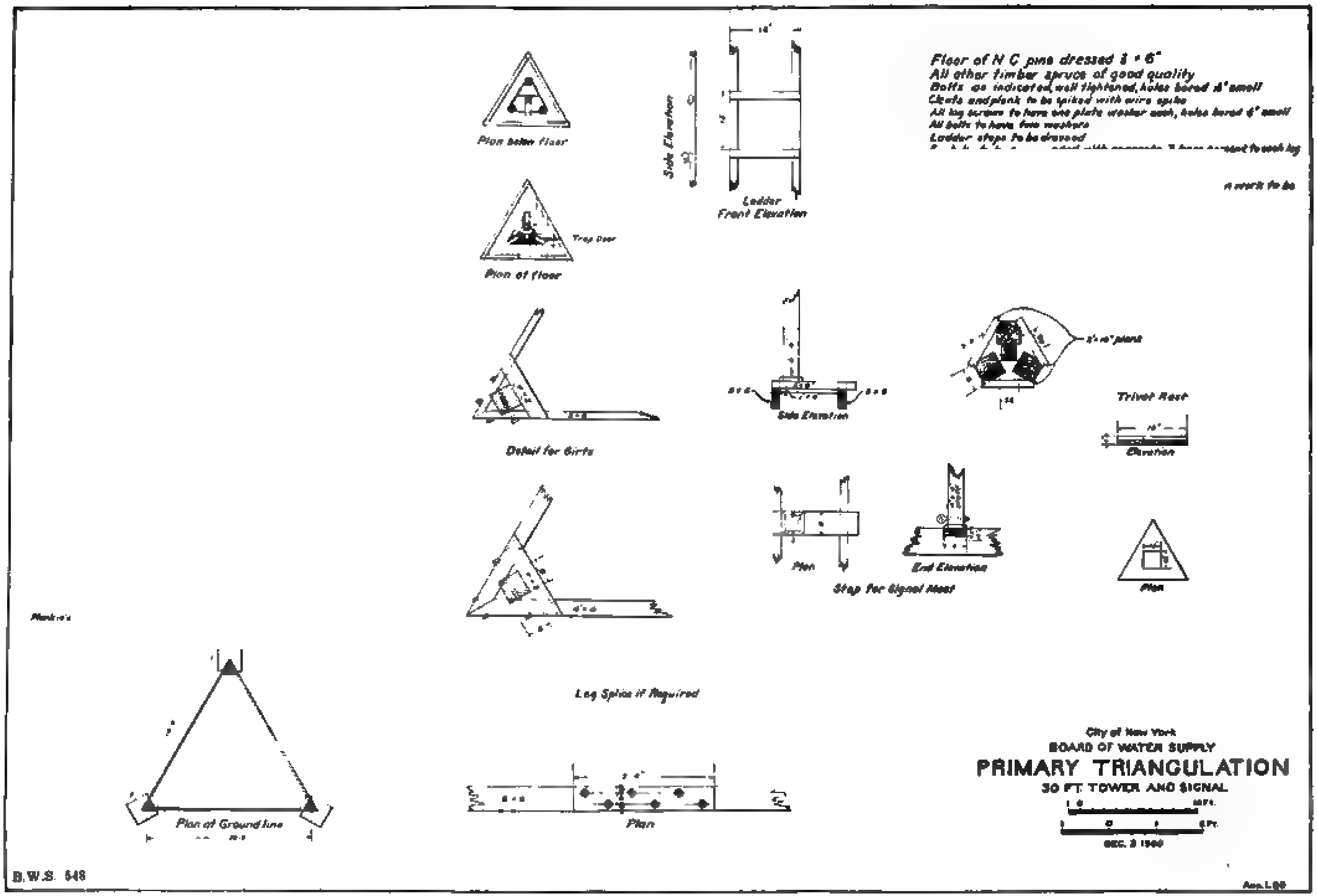
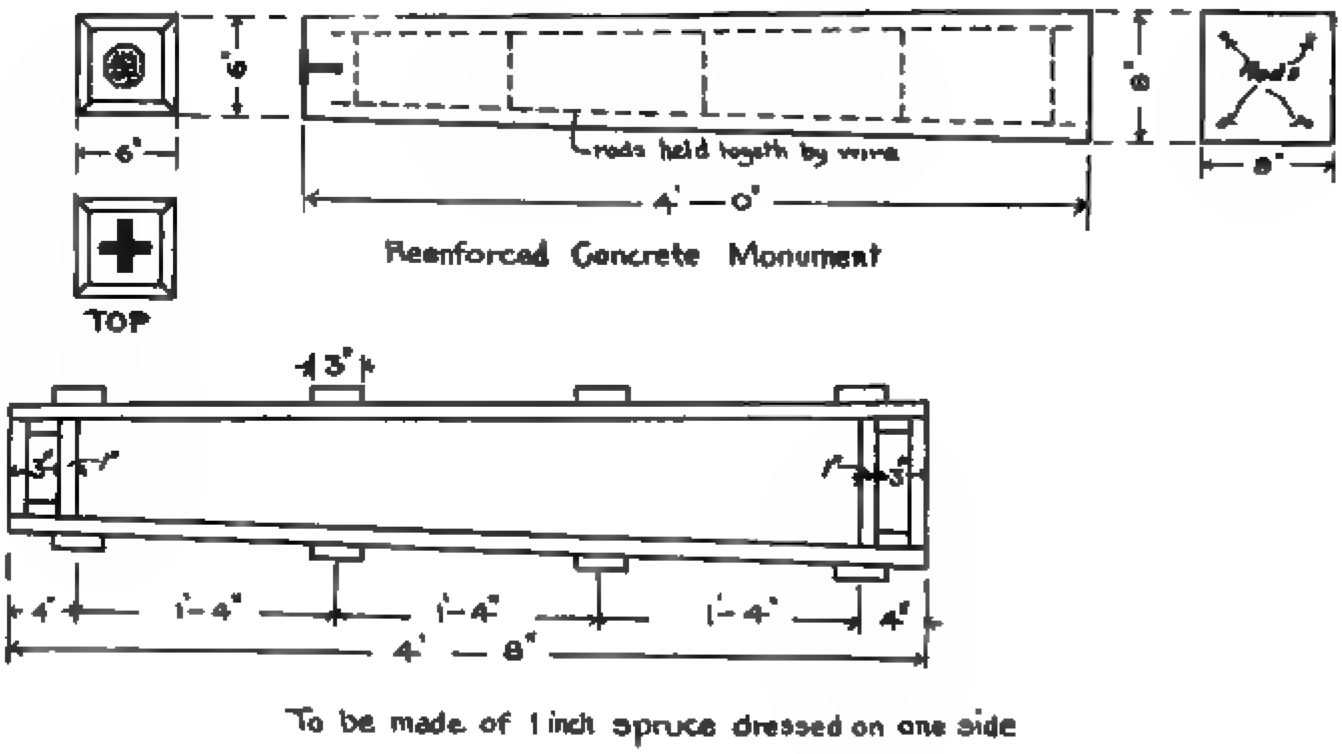
SHEET 171



Detail of Ladder
Section
Plan
Footing for Legs
City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
FOUR POST TRIANGULATION TOWER
50 Feet High


Floor of N C pine dressed 3 × 6"
All other timber spruce of good quality
Plan below floor
Plan of floor
Trap Door
Side Elevation
Ladder
Front Elevation
Detail for Girts
Side Elevation
2" × 10" plank
Trivet Rest
Elevation
Plan
End Elevation
Step for Signal Mast
Plan
Leg Splice if Required
Plan
Plan of Ground line
City of New York
BOARD OF WATER SUPPLY
PRIMARY TRIANGULATION
30 FT. TOWER AND SIGNAL
B.W.S. 548



City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
FORM FOR REENFORCED CONCRETE MONUMENT

B.W.S. 509

Acc L 505

Conditions of Coast Survey Stations Investigated in Suffolk County

WELWOOD'S CUPOLA. Octagonal cupola painted gray on 2-story frame dwelling house of F. D. Neville, near northwest corner of Merrick road (Main street) and Broadway in Lindenhurst (formerly Breslau). Unchanged.

BRESLAU YELLOW SPIRE. Church is south of railroad track and about ½ mile west of station in Lindenhurst (formerly Breslau). Reported to have been moved.

BRESLAU WHITE SPIRE. St. John's Lutheran church painted gray, on the north side of Palmer avenue (formerly Fallers Laben avenue) opposite School street, Lindenhurst. Apparently unchanged.

BABYLON BAPTIST CHURCH. Most westerly spire in the village, is painted light gray with green trimmings. Church is on the northeast corner of Carll avenue and Main street (South Country road). Unchanged.

BABYLON METHODIST CHURCH. Church stands on east side of Deer Park avenue on the corner of James street, a block and a half south of the railroad, and is painted yellow. Unchanged.

BABYLON PRESBYTERIAN CHURCH. Tall white spire with clock, on the north side of Main street, just east of Deer Park avenue. Unchanged.

BABYLON EPISCOPAL CHURCH. The most easterly spire in Babylon (is really in West Islip), on the north side of South Country road, about ⅔ mile east of Babylon. Church has been covered with concrete stucco and is of a gray color. Unchanged.

RULAND. Hubs in place as described. Unchanged.

BAYSHORE STONE SPIRE. Church has been moved.

PATCHOGUE SCHOOLHOUSE. Two-story frame building with cupola painted dark brown, on east side of Ocean avenue, just north of railroad and about 500 feet east of station. Unchanged.

BELLPORT CHURCH SPIRE. White spire of Bellport Presbyterian church on the north side of South Country road (East Main street) just east of Rector avenue. Unchanged.

OSBORN. Station on Thomas Osborn's hill. Tile drain filled with concrete was found in good condition. Reference stakes not looked up.

TERRY. Tile drain filled with concrete and reference stakes found in good condition.

MASURY WINDMILL. This station was burned about four years ago.

MORICHES METHODIST CHURCH SPIRE. This church was moved in 1907.

MORICHES PRESBYTERIAN CHURCH SPIRE. This spire has not been changed since 1886.

BROOKLYN HOUSE FLAGSTAFF. This building was burned in 1907.

EASTPORT CLUB HOUSE (WINDMILL). This windmill is unchanged.

Conditions of Coast Survey Stations Investigated in Nassau County

PIERSALL'S METHODIST CHURCH SPIRE. Tall tapering gray spire on the east side of Washington place, Lynbrook, between Merrick road and the Montauk division of the Long Island Railroad. Unchanged.

ROCKVILLE CENTER METHODIST CHURCH. Church was burned about 10 years ago and has been replaced by another church building.

BALDWINSVILLE METHODIST CHURCH. Tall tapering white spire of church on the north side of Merrick road, about ¼ mile south of Baldwin station. Unchanged.

FREEPORT PRESBYTERIAN CHURCH. Church on the west side of Church street, between Pine street and Merrick road south of Freeport station; it is painted gray. Unchanged.

FRY'S CUPOLA. Square cupola surmounted by finial on gray French roofed house on the northeast corner of Bellmore avenue and Merrick road in Bellmore; now owned by G. F. Newland. Unchanged.

EPISCOPAL SPIRE (SOUTH OYSTER BAY). Small octagonal spire with gilt cross on Episcopal church on the north side of Merrick road about ½ mile east of Massapequa. It is partly surrounded by trees that are nearly as high as the top of the spire. Unchanged.

APPENDIX B

SECONDARY LEVELS

BY JOHN L. HILDRETH, JR., ASSISTANT ENGINEER

In order to obtain bench-marks for closures of the stadia traverses, and to secure elevations of water in the wells and in the streams and ponds, secondary lines of levels were run from the base-line and primary circuits established from the Smith Pond bench of the Department of Water Supply, by Assistant Engineer Goodman in 1906 and 1907.

PRIMARY BENCH LEVELS

In accordance with the recommendation of the latter, in his report of February 16, 1907, standard bench-marks were subsequently placed at Melville, Babylon, Patchogue, Center Moriches, Westhampton, Port Jefferson, Lake Grove, Ridge and Yaphank; and bolts were set in permanent masonry structures at Blue Point, Wardenclyffe, Brookhaven, Riverhead, Calverton and Great River. The elevations of these new primary bench-marks are shown in Table 61, page 658, which may be considered as supplementing the report of Assistant Engineer Goodman of February 16, 1907. The primary bench-marks previously reported are shown in Table 60, page 649.

All elevations in these tables refer to the datum plane assumed for the Long Island work in 1907, which is 1.72 feet below that of the Brooklyn Water Department, on which Assistant Engineer Goodman's first work of 1906-1907 was done.

SECONDARY LEVELS

For the secondary levels, small parties were made up at the three offices maintained at Babylon, Patchogue and Center Moriches, respectively. These level parties comprised an instrument man and one or two rodmen. An 18-inch Buff and Buff " Dumpy " level with one horizontal wire was used, with either target or self-reading rods. The target rods were divided to $\frac{1}{10}$ foot, with vernier reading to half hundredths, the thousandth being estimated. The self-reading rods which were used on a few of the runs were 10 feet long, 4 inches

wide, $1\frac{1}{4}$ inches thick at the bottom, and $\frac{1}{2}$ inch thick at the top stiffened by a strip $\frac{7}{8}$ inch by $1\frac{1}{4}$ inches screwed to center of the back; these rods were graduated to tenths and 2/100 foot, and proved much more satisfactory than the target rods, and gave equally good closures. Nails were used for turns in most cases. Sights were from 150 to 250 feet, according to weather conditions, and in all cases were made equal in order to eliminate all instrument errors.

Bench-marks were usually railroad spikes or lag screws, driven into telegraph poles or the roots of trees; but stone monuments and masonry structures of all kinds were utilized wherever possible.

In the formula, $E = C \sqrt{M}$ in miles, in which E equals the error of closure in feet, C a constant, and M the distance between bench-marks in miles; C was not allowed to exceed 0.03. The average value of C as computed from the closures of all the secondary levels was 0.02.

The following table gives the main circuits and the bench-marks between which they were run; also the distance, closure, and error of closure as computed from the above formula:

Number of miles of levels run	899.3
Number of bench-marks established	
Precise, replacing unsatisfactory points of Assistant Engineer Goodman	15
Secondary	833
Test-wells, leveled on for ground-water elevation as well as for bench-marks	510
Total	1,358
Total cost, salaries, expenses, etc., including office work (no executive)	\$9,135.47
Cost per mile, of which about one-half was office work	\$10.15

TABLE 59

Bench-mark	to Bench-mark	Distance Miles	Error of Closure E	$C = \frac{E}{\sqrt{\text{Distance (in Miles)}}}$
U. S. G. S.	B. C.	3.4	.053	0.0287
2	U. S. G. S.	4.4	.039	0.0186
U. S. G. S	B. C.	2.6	.024	0.0149
B. D.	U. S. G. S.	3.8	.047	0.0242
B. E.	B. F.	1.3	.035	0.0307
B. F.	B. F.	5.6	.110	0.0465
B. F.	B. C.	4.5	.016	0.0075
B. C.	B. 2	3.4	.009	0.0049
B. 3	B. 5	3.2	.102	0.0570
8	B. 3	4.8	.021	0.0095
26	B. 7	2.8	.035	0.0209
B. 7	B. 10	4.1	.000	0.0000
B. 10	B. 11	2.5	.011	0.0070
B. 2	42	5.5	.220	0.0938
8	8	4.6	.069	0.0318
7	71	1.3	.030	0.0263
8	79	2.9	.038	0.0223
63	84	1.9	.036	0.0261
80	B. 128	6.1	.098	0.0396
71	B. 127	2.8	.006	0.0036
B. 128	B. 127	1.0	.002	0.0020
Sher. No. 2	B. 4	2.5	.120	0.0759
176	B. 5	2.1	.000	0.0000
177	B. 7	2.2	.021	0.0142
178	B. 8	1.1	.051	0.0486
B. 3	50	5.0	.076	0.0340
80	87	2.1	.051	0.0352
88	35	3.5	.055	0.0294
27	49	6.9	.089	0.0339
50	B. 110	2.5	.082	0.0519
B. 110	52	2.2	.002	0.0013
55	B. 110	2.2	.004	0.0027
B. 2	B. A.	1.5	.012	0.0098
129	50	1.0	.059	0.0590
47	148	1.1	.012	0.0114
179	B. 11	2.6	0.116	0.0706
B. 11	B. 8	2.6	0.026	0.0162
B. 8	B. 7	1.1	0.000	0.0000
B. 7	B. 5	1.5	0.017	0.0139
B. A	B. C.	1.9	0.064	0.0464
B. F.	23	3.6	0.039	0.0256
T. W. 91	B. 14	2.0	0.002	0.0014
Patchogue Geol.	Holtsville Geol.	12.0	0.005	0.0014
Prim. No. 24	Prim. No. 17	15.3	0.198	0.0506
Patchogue Geol.	Holtsville* Geol.	7.2	0.020	0.0075
Prim. No. 27	Prim. No. 29	3.3	0.018	0.0099
249	241	3.5	0.008	0.0043
249	Prim. No. 29	7.0	0.033	0.0125
231	309–231	1.0	0.001	0.0010
Prim. No. 11–13	358	8.8	0.063	0.0212
212	346-212	1.7	0.004	0.0031
Prim. No. 11	Prim. No. 13	2.3	0.010	0.0065
Prim. No. 13	No.372 & Prim.No.11.	2.9	0.033	0.0194
Prim. No. 17	358	8.5	0.135	0.0465
Prim. No. 17	Prim. No. 16	2.4	0.041	0.0265
Prim. No. 17	216	3.3	0.004	0.0022
217	442–217	3.0	0.040	0.0231
202	390	3.4	0.002	0.0011
441	461–441	1.2	0.010	0.0091
270	466–270	1.6	0.020	0.0158
Prim. No. 53	Dug well north of Calverton	3.0	0.036	0.0208

TABLE 59 (*Concluded*)

Bench-mark	to Bench-mark	Distance Miles	Error of Closure E	$C = \frac{E}{\sqrt{\text{Distance (in Miles)}}}$
Geol. No. 19	492 and No. 19 Geol.	1.0	0.006	0.0060
459	495–459	1.0	0.004	0.0040
80	590	4.1	0.076	0.0375
B. 19	Bs. 19	3.0	0.031	0.0179
B. 455	B. 455	3.2	0.013	0.0073
B. 455	B. 443	3.0	0.029	0.0167
B. 452	B. 429	3.3	0.077	0.0424
BB. 34	B. 427	2.5	0.003	0.0019
BB. 34	BB. 34	1.0	0.015	0.0150
B. 427	B. 427	3.0	0.017	0.0098
B. 425	B. 411	4.0	0.002	0.0010
B. 425	B. 35	2.5	0.023	0.0145
B. 422	B. 422	1.0	0.008	0.0080
B. 412	B. 437	2.5	0.027	0.0171
B. 440	B. 440	1.0	0.017	0.0170
BB. 36	BB. 37	5.5	0.062	0.0264
B. 410	BB. 37	2.5	0.011	0.0070
BB. 37	U. S. G.	2.0	0.014	0.0099
B. 402	B. 420	2.3	0.007	0.0046
B. 402	B. 402	6.0	0.022	0.0090
B. 461	B. 461	1.5	0.001	0.0008
B. 420	B. 420	3.5	0.018	0.0096
B. 420	B. 420	6.5	0.028	0.0110
Well 446	Well 446	3.5	0.054	0.0288
504	504	4.4	0.060	0.0286
B. 41	503	1.2	0.003	0.0027
503	504	1.3	0.008	0.0070
503	512	1.4	0.002	0.0017
501	502	1.4	0.064	0.0541
B. 41	501	3.8	0.010	0.0051
B. 41	503	2.4	0.034	0.0220
B. 45	509	3.1	0.020	0.0114
B. 41	T. P.	1.8	0.047	0.0350
524	524	2.7	0.034	0.0207
B. 52	525	2.5	0.005	0.0032
530	Riverhead U.S. B.M.	2.8	0.008	0.0048
531	Riverhead U.S. B.M.	3.6	0.077	0.0406
538	538	4.3	0.057	0.0275
531	531	11.2	0.081	0.0242
534*	529	6.3	0.074	0.0295
549	535	2.9	0.074	0.0434
B. 51	B. 159	1.0	0.027	0.0270
B. 161	B. 161	2.8	0.001	0.0006
548	B. 176	6.0	0.099	0.0404
B. 164	B. 165	1.2	0.029	0.0265
555	B. 164	4.7	0.021	0.0097
573	B. 153	1.7	0.010	0.0076
B. 164	B. 164	6.0	0.030	0.0123
B. 164	585	1.1	0.009	0.0086
B. M. 34	B. 68	6.4	0.069	0.0273
B. 67	B. 68	4.3	0.007	0.0034

Average value of C = 0.02 *Via Medford

TABLE 60

PRIMARY CIRCUIT LEVELS ①			
LOCATION	B.M.	ELEVATION	DESCRIPTION
Rockville Centre	Smith's Pond	12.712	□ cut E rim of pumpwell at Pumping Sta. N.W. Cor. of Smith's Pond
Rockville Centre	Geolg'l.	27.012	Bronze tablet N.E. Corner Observer & Village Ave.; 20'N. of corner of building and 1' above ground.
Baldwin	B"O"	28.072	Knob S.E. Cor. Signal Post # 202 L.I.R.R. Post is opposite ℄ of Milburn Reservoir.
Baldwin	B"N"	19.140	Knob S.E. Cor. Culvert 400'W. of Baldwin R.R. Sta.; 30' N. of Track.
Freeport	B"M"	~~17.906~~	Knob S.E. Cor. Signal Post # 228, 100' E of Freeport R.R. Sta. DESTROYED
Merrick	Geolg'l.	19.517	Bronze cap of pipe sunk in ground 300'W. of Merrick R.R. Sta. B.M. is 37'W. of road, 14'S. of near rail and 3/4' above Ground
Bellmore	B"L"	18.590	Knob S.E. Cor. of Signal Post # 256 L.I.R.R. 300'W. of Bellmore R.R. Sta.
Wantagh	B"K"	20.291	Bolt root Locust Tree in front of Fountain Hotel 100' W. of Wantagh R.R. Sta.

B.W.S. 474

PRIMARY CIRCUIT LEVELS ②			
LOCATION	B.M.	ELEVATION	DESCRIPTION
Seaford	B"J"	24.511	Bolt root Oak Tree 200'W. of Seaford R.R. Sta. 60'S. of track.
Massepequa	Bh	20.252	+ cut on door step waiting room N.S. Massepequa R.R. Sta. 20' W. of N.E. Corner
Amityville	BG	25.584	Knob N.W. Cor. Signal Post # 303 about 1000' W. of Carmen's Creek. B.M. near road crossing.
Amityville	BF	26.525	+ cut N.W. Corner Amityville R.R. Sta. 2' E. of Corner
Copaigue	Be	25.595	Knob N.W. Corner Signal Post # 323 about 350'E. of Copaigue R.R. Sta.
Copaigue	Bd	22.902	Knob N.W. Corner Signal Post # 329 about 40'W. of Copaigue Road. B.M. is 1/2 Mile E of Copaigue R.R. Sta.
Lindenhurst	Bc	22.392	Bolt root Maple tree 100' of Lindenhurst R.R. Sta. B.M. is at E.S. Road
Lindenhurst	Bb	18.399	Knob S.W. Cor. Signal Post # 346 about 8/10 Mile E. of Lindenhurst R.R. Sta.
Babylon	Ba	17.207	Knob N.E. Corner Signal Post # 357 about 1000' E. of R.R. Junct. 1 Mile W. of Babylon R.R. Sta.

B.W.S. 472

TABLE 60 (*Continued*)

PRIMARY CIRCUIT LEVELS ③			
LOCATION	B.M.	ELEVATION	DESCRIPTION
Babylon	Geolg'l.	17.247	Bronze plate cemented to N.W. Corner of M.E. Church at E. side of Deer Park Ave. B.M. about 3' above ground
Babylon	B 1	13.589	Nail at root of Elm tree in front of M.E. Church at E.S. Deer Park Ave.
Babylon	B 2	19.484	Nail at root of Elm tree alongside fence 75' S of track and 250' E. of Babylon R.R. Sta.
Babylon	B 3	23.841	Nail in root large oak tree at Higbie's Ave. crossing; 40' S. of track and 25' E. of road.
Babylon	B 4	24.737	Knob on N.W. Corner Signal Post #381 L.I.R.R. at S.S. track 2/10 mile E. of 38th Mile Post.
Bay Shore	B 5	27.007	Nail in root oak tree E.S. of Saglikos Manor Lane about 50' S. of R.R. track
Bay Shore	B 6	23.599	Knob at N.W. Corner Signal Post #397 L.I.R.R. 3/10 Mile W. of Mile Post 40
Bay Shore	B 7	21.404	Knob on W. End of Concrete Wall 200'S. of Bay Shore Sta. and 30' E. of Park Ave. B.M. is 3' above ground

B.W.S. 461

PRIMARY CIRCUIT LEVELS. ④			
LOCATION	B.M.	ELEVATION	DESCRIPTION
Bay Shore	B 8	14.923	Nail at root large oak tree 350' E. of Awixa Ave. and 50' S. of track.
Islip	B 9	11.365	Knob S.E. Corner Signal Post #422 N.S. track
Islip	B 10	23.991	Bolt in root large oak tree E.S. Islip Ave. 75' N of track and 500' E. of Islip R.R. Sta.
East Islip	B 11	22.455	Bolt in root Oak tree E.S. Carleton Ave. 75' N. of track
Great River	B 12	26.879	Knob N.W. Corner of Signal Post #447 S.S. track 1/2 Mile W of Great River R.R. Sta.
Great River	B 13	28.055	Bolt root Oak Tree 75' N. of Great River R.R. Sta.
Great River	B 14	6.183	Knob S.W. Corner Bridge over Connetquot Brook. Knob is 3 6/10 feet S. of rail.
Oakdale	B 15	12.714	Bolt root Giant Oak tree in back of Freight Storehouse at Brookdale R.R. Sta.
Oakdale	B 16	27.094	Bolt root Oak tree 100' E. of Locust Ave. and 200' S. of track.
Sayville	B 17	22.918	Bolt root Oak tree 250' E. of Sayville RR Sta and 100' S. of track.

B.W.S. 460

TABLE 60 (*Continued*)

PRIMARY CIRCUIT LEVELS. (5)			
LOCATION	B.M.	ELEVATION	DESCRIPTION
Bayport	B18	7.066	Bolt at top of Sill over ℄ of Pile at N.E. Cor. of Bridge over creek 3/4 Mile W. of Bayport R.R. Sta. B.M. is 2.8' below rail.
Bayport	B23	26.831	Bolt root Oak tree at R.R. crossing 45' N. of track and 300' E. of Bayport R.R. Sta.
Bluepoint	B24	23.153	Knob S.W. Corner Highway Bridge 300' W. of Bluepoint R.R. Sta. B.M. is 3' below rail
Patchogue	Geolg'l.	16.227	Bronze plate N.E. Corner of Freight House about 700' W. of Patchogue R.R. Sta. B.M. is about 4' above Ground
East Patchogue	B26	21.122	Bolt root cherry tree 500' E. of Country Road crossing and 50' N. of track. B.M. is 150' E. of large white house.
Patchogue	B25	18.802	+ Cut on door sill Patchogue R.R. Sta. Cut is 5' E. of N.W. Corner.
Hagerman	B27	29.647	Bolt root Oak tree 75' E. of .... Road and 35' S. of R.R. track. B.M. is 4/10 Mile W. of Hagerman R.R. Sta.
Bellport	B28	44.401	Bolt root Oak tree near R.R. Crossing 35' S. of track and 15' from Mile Post 57 L.I.R.R.
Bellport	B29	45.158	Bolt root of Pine Tree 125' S. of Bellport R.R. Sta.

B.W.S. 458

PRIMARY CIRCUIT LEVELS (6)			
LOCATION	B.M.	ELEVATION	DESCRIPTION
Bellport	B30	54.433	Bolt Pine tree W.S. Cemetery Road 125' N. of R.R. Crossing
Brook Haven	Geol. #19	20.633	Knob S. end of 3rd step of W. abutment Highway Bridge #81 L.I.R.R. B.M. is 6' above S. Country Road 4/10 Mile W. of Sta.
Brook Haven	B31	21.704	Bolt root Oak tree 60' N. of track and 40' E. of road crossing R.R. 1 1/10 Mile E. of Brookhaven R.R. Sta.
South Haven	B32	25.483	Bolt root Oak tree 75' N. of track at W.S. of the Hay Ave.
Mastic	B33	46.632	Bolt root Oak tree 40' S. of track, about 150' from Telegraph Pole #2582, 1 Mile W. of Mastic R.R. Sta. About 6' above rail.
Mastic	B34	31.113	Bolt root of Large Oak tree 100' S. of Mastic R.R. Sta.
Center Moriches	B35	27.997	Bolt root of Twin trees at South Country Road Crossing 9/10 Mile W. of Centre Moriches R.R. Sta. B.M. is inside Fence 30' N. of track and 20' E. of Road.
Centre Moriches	B36	~~32.140~~	Knob S.W. Corner of base of Signal Post in front of Centre Moriches R.R. Sta. DESTROYED
East Moriches	B37	36.051	Bolt root Cherry tree alone in field 650' E. of East Moriches R.R. Sta. and 200'. N. of track.
Eastport	Geolg'l.	30.490	Centre of cover of pipe sunk in ground 200' N. of Eastport R.R. Sta. B.M. is 40' E. of Oak tree; 27' S. of ℄ Road and 2" above ground.

B.W.S. 457

TABLE 60 (*Continued*)

PRIMARY CIRCUIT LEVELS

LOCATION	B.M.	ELEVATION	DESCRIPTION (7)
Eastport	B38	29.966	Bolt root tree 300' NE South Country Rd Crossing 1 Mile E. of Eastport. BM is 200' N of triangulation Sta LAT = 40-49-20 LONG = 72-42-52
Speonk	B39	36.405	Bolt root Locust Tree 150' W of Speonk R.R. Sta. 20' S of track LAT = 40-49-12 LONG = 72-42-10
Westhampton	B40	42.341	Bolt root Oak tree S.W. Corner intersection Rds N to Riverhead W to Eastport and 125' N of R.R. Crossing LAT = 40-49-32 LONG = 72-40-42
Westhampton	B41	46.668	+ Cut top of bolt at base Signal Post in front Westhampton R.R. Sta LAT = 40-49-48 LONG = 72-39-10
Westhampton to Riverhead Road	B42	68.117	Bolt root Pine tree W.S. Road 5850' N of Westhampton R.R. Sta LAT = 40-50-46 LONG = 72-38-58
Westhampton to Riverhead Road	B43	87.763	Bolt top of Stump near blazed trees 11500' N of Westhampton R.R. Sta. BM is E.S. Rd LAT = 40-51-38 LONG = 72-38-46
Westhampton to Riverhead Road	B44	83.917	Bolt root Oak tree W.S. Rd 1600 S of Fork of Rds from Riverhead SW to Westhampton, SE to Quogue. BM is 5550' N of BM B43 LAT = 40-52-28 LONG = 72-38-24
Westhampton to Riverhead Road	B45	54.406	+ Cut E. Edge pipe at center of well 50' S. of Fork of Rds - 3 Miles S. of Riverhead - Rds SW to Westhampton - SE to Quogue LAT = 40-52-45 LONG = 72-38-15
Riverhead	B46	21.897	Bolt root Large pine at turn of Road 30' W of ℄ Road BM is 1¼ Miles N. of B45 LAT = 40-53-40 LONG = 72-38-50
Riverhead	B47	24.131	Bolt root Oak tree 50' W of ℄ Rd 40' S of House Wallace Nesbitt BM is 1600' S of Inter of Rds and 6100' N of B46 LAT = 40-54-38 LONG = 72-39-22

B.W.S. 455

PRIMARY CIRCUIT LEVELS

LOCATION	B.M.	ELEVATION	DESCRIPTION (8)
Riverhead	B48	6.578	Knob N.W. Corner Bridge Culvert over Peconic River. BM is 2' N of Spring Line of Arch and about 150' S of Rolled Mill LAT = 40-54-55 LONG = 72-39-47
Riverhead	Geod'l	28.565	Bronze Tablet at N.E. Cor. Riverhead Court House 2' above ground LAT = 40-55-08 LONG = 72-39-58
Riverhead	B49	22.158	Knob N.W. Corner Highway Bridge ½ Mile W. of Riverhead R.R. Sta LAT = 40-55-10 LONG = 72-40-38
Riverhead	B50	20.830	Bolt root Large Oak S.S. Middle Country Rd W.S. of house of F.W. Conklin. BM is 200' S of track and 1 Mile W of B49 LAT = 40-55-00 LONG = 72-41-50
Calverton	B51	27.893	Bolt root Oak tree opposite Ice House 50' N of R.R. track and 200' E of Road Crossing 3 Miles W of Riverhead Sta. LAT = 40-54-57 LONG = 72-43-00
Calverton	B52	70.181	Bolt root Oak tree at house W.S. Road 150' S of Intersection of Rds 3¾ Miles W. of Riverhead R.R. Sta LAT = 40-55-28 LONG = 72-43-43
Calverton	B53	68.113	Bolt root Large Oak at Intersection Rds 1½ Miles N. of Calverton R.R. Sta. LAT = 40-55-36 LONG = 72-44-52
Middle Country Road	B54	84.730	Bolt root Cherry tree at house of John Lee 100' E of Intersection of Roads 2 Miles N.W. of Calverton LAT = 40-55-44 LONG = 72-46-20
Middle Country Road	B55	71.665	Bolt root Oak tree in angle 100' W of Fork of Roads 4 Miles S.E. of Wading River LAT = 40-55-42 LONG = 72-47-28
Middle Country Road	B56	60.221	Bolt root twin Oak 25' N of ℄ Road 5900' W of B55 LAT = 40-55-25 LONG = 72-48-44

B.W.S. 454

TABLE 60 (*Continued*)

PRIMARY CIRCUIT LEVELS

LOCATION	B.M.	ELEVATION	DESCRIPTION (9)
Middle Country Road Manorville	Geol'l	84.283	Bronze Cap top of pipe at lane 4100' E of Intersection of Rds 3 Miles S. of Wading River. BM 1' above ground LAT-40-55-12 LONG.-72-49-12
Middle Country Road	B57	75.461	Bolt root Oak tree S.E. Corner Inter. Roads 3 Mile S. Wading River LAT-40-54-55 LONG.-72-50-05
Middle Country Road	B58	63.622	Bolt root Pine tree 25' N of Rd and 5100' W of B57 LAT-40-54-30 LONG-72-51-00
Middle Country Road	B59	82.449	Bolt root Small pine 40' N of Fork of Rds 5 Miles SE of Rocky Point LAT-40-54-16 LONG.-72-51-40
Ridge	Geological #74	74.616	Nail root Oak tree S.W. Corner Intersection Rds 4 Miles S.W. of Wading River LAT-40-53-50 LONG.-72-53-00
Middle Country Road	B60	109.537	Bolt root Giant Tree at Randall's House at Intersection of Roads 2 Miles E of Artist Lake LAT-40-53-30 LONG.-72-54-12
Middle Island	B61	70.992	Bolt root small oak S.W. Inter Roads 1¼ Miles E. of Middle Island Post Office LAT-40-53-20 LONG.-72-54-52
Middle Island	B62	61.315	Bolt root Oak tree at Artist Lake Road Intersection ½ Mile E of Middle Island Post Office LAT-40-53-12 LONG-72-55-55
Middle Island	Geol'l	57.949	
Middle Island	B63	82.687	Nail root Cherry tree at Fork of Roads S to Yaphank BM is 100' S of Middle Island Post Office LAT-40-53-00 LONG.-72-56-28

B.W.S. 459

PRIMARY CIRCUIT LEVELS			(10)
LOCATION	B.M.	ELEV.	DESCRIPTION
MIDDLE ISLAND	B.64	51.445	Nail root large oak E. side road at intersection of private road 5700' S. Middle Island Post Office. Lat.-40-52-12 Long.-72-56-02
MIDDLE ISLAND	B65	56.368	Nail root large oak E. side road at fork of roads 1.6 mi. S. of Middle Island P.O. Lat.-40-51-50. Long.-72-56-15.
YAPHANK	B66	64.331	Bolt root oak W. side road inside wire fence at Vanderbilt Farm. B.M. is 100' S. of lane intersection, 8/10 mi. N. of Yaphank. Lat.-40-51-14. Long.-72-56-15.
YAPHANK	B67	52.705	Bolt root giant oak 1000' E. inter. roads and ½ mi. W. Yaphank P.O. Lat.-40-50-30. Long.-72-55-52
YAPHANK	B68	33.729	Bolt root giant walnut W. side road 150' N. Yaphank Mill. Lat.-40-50-10. Long.-72-54-58.
YAPHANK	B69	51.935	Bolt root oak W. side road 400' W. Yaphank R.R. Sta. B.M. is 50' S. of track. Lat.-40-49-30. Long.-72-55-00.
YAPHANK	B70	39.658	Bolt root oak W. side road 200' N of house of Terwilliger 1¼ mi. S. of Yaphank R.R. Sta. Lat.-40-48-32 Long.-72-54-56.
BROOKHAVEN	B71	30.921	Bolt root 4 branch oak S.W. corner inter. roads ½ mi. N. of Brookhaven R.R. Sta. Lat.-40-47-25. Long.-72-54-50

B.W.S. 462

TABLE 60 (*Continued*)

PRIMARY CIRCUIT LEVELS (11)

LOCATION	B.M.	ELEV.	DESCRIPTION
MIDDLE ISLAND	Geol. #156	155.886	○ Cut top boulder front Bailey's house ½ mi. W. Middle Id. P.O. Lat.: 40-52-56 Long. = 72-57-03.
MIDDLE ISLAND	B 73	91.274	Bolt root cherry S. side road 100' E. intersection roads 1 mi. W. Middle Island P.O. Lat.: 40-52-53. Long. = 72-57-37.
MIDDLE ISLAND	B 75	99.798	Bolt root oak at Fork Road 500' E. of C.H. Hogan's Hotel. Lat.: 40-52-39. Long. = 72-58-18.
CORAM	B 76	86.646	Bolt root walnut N. side road 100 E. brick bldg. of E. Davis. Lat.: 40-52-21. Long. = 72-59-30.
CORAM	B 77	94.900	Bolt root willow at fork of roads S.E. to Coram Hill. Lat. = 40-52-09. Long. = 73-00-06.
SELDEN	B 78	158.411	Bolt root oak N. side road at top of hill ¼ mi. E. of Selden P.O. in front of house of Mr. Yarrington. Lat.: 40-52-06 Long. = 73-01-12
SELDEN	B 79	112.319	Bolt root oak in front of church at Fork Roads. B.M. at bottom of hill 700' W. of B 78. Lat. = 40-52-06 Long. = 73-01-18.
SELDEN	B 80	104.965	Bolt root oak S. side road opposite barn of Kessner at W. end of Selden Village. B.M. is 600' W. of cross roads. Lat. = 40-51-55 Long. = 73-02-20.
SELDEN	B 81	99.207	Bolt giant oak S. side road 200' N. Ruland residence. B.M. is 1¼ mi. W. of Selden. Lat. = 40-51-43. Long. = 73-03-30.

B.W.S. 456

PRIMARY CIRCUIT LEVELS (12)

LOCATION	B. M.	ELEV.	DESCRIPTION
NEW VILLAGE	B 82	96.349	Bolt root large oak N.E. cor. inter. roads at New Village. Lat. = 40-51-31. Long. 73-04-40.
LAKE GROVE	B 85	106.303	Bolt root oak W. side road 400' N. house of L. Staden. B.M. is about ½ mi. S. Lake Grove P.O. Lat.: 40-50-46 Long. = 73-06-47.
LAKE GROVE	B 86	110.364	Bolt root large oak N.W. of 5 Corners 1 mi. S. Lake Grove P.O. Lat. = 40-50-18. Long. = 73-06-34.
RONKONKOMA LAKE	B 87	65.255	Center of monument at N.E. cor. fork of roads 1.7 mi. N Ronkonkoma R.R. Sta. B.M. is 40' E. of E. bank of Lake. Lat.: 40-49-42. Long. 73-07-00
RONKONKOMA	B 88	115.582	Bolt root chestnut N.E. cor. inter. rds. ½ mi. S. Ronkonkoma Lake. Lat. = 40-49-08. Long. = 73-07-08.
RONKONKOMA	Geolgl.	109.066	Bronze cap of pipe sunk in ground at E. edge of platform of Ronkonkoma R.R. Sta. 40' N. of rail Lat.: 40-48-28. Long. = 73-06-38.
RONKONKOMA	B 89	101.165	Bolt root oak E. side road 30' S house of Henry Milton, 1000' S. of R.R. track. Lat. = 40-48-16. Long. = 73-07-28.
BOHEMIA	B 90	80.602	Bolt root young oak S.E. cor. inter. rds. 1 mi. N. of Bohemia. Lat.: 40-47-12. Long. = 73-07-18.
BOHEMIA	B 91	65.526	Bolt root oak N.E. cor. inter. rds. Church Ave. and Ocean Ave. at Bohemia. Lat. = 40-46-08. Long. = 73-07-10.
OAKDALE	B 92	50.005	Bolt root young oak W. side road 850' S. of turn in road. B.M. is 6150' N. Oakdale R.R. Sta Lat. = 40-45-20. Long. = 73-07-20.

B.W.S. 470

TABLE 60 (*Continued*)

PRIMARY CIRCUIT LEVELS (13)

LOCATION	B.M.	ELEV.	DESCRIPTION
LAKE GROVE	B83	106.256	Bolt root oak at fork roads 1mi. E. of Lake Grove. Lat. = 40-51-30. Long. = 73-05-37.
LAKE GROVE	B84	106.135	Bolt root large walnut N.E. cor. intersection roads 3½ mi N. Ronkonkoma R.R. Sta. Lat. = 40-51-36. Long. = 73-06-42.
LAKE GROVE	B98	97.930	Bolt root oak N.E. cor. inter. rds. ¾ mi. W. of Lake Grove Lat. = 40-51-42 Long. = 73-07-40
MIDDLE C'NTRY ROAD	B99	118.185	Bolt root young oak 400' W. Camden Ave. 25' N.E. road and 200' W. house C. Henderson. 1¾ mi. W. Lake Grove. Lat. = 40-51-41. Long. = 73-08-42.
SMITHTOWN BR.	B100	125.450	Bolt root oak at inter. roads 2 mi. E. Smithtown Branch Lat. = 40-51-35. Long. = 73-09-35.
SMITHTOWN BR.	B101	78.284	Bolt root oak S.W. cor. fork of rds. 1mi. E. Smithtown Branch Lat. = 40-51-20. Long. = 73-10-22.
SMITHTOWN BR.	B102	62.432	□ Cut S.E. cor. top step at entrance to house of Mrs. Chas. Miller S. side road opposite Smithtown Branch P.O. Lat. = 40-51-21. Long. = 73-11-21.
SMITHTOWN BR.	B103	64.069	+ Cut top bolt N.E. cor. signal post at Smithtown R.R. Sta. Lat. = 40-51-21. Long. = 73-11-56.
SMITHTOWN	Geog'l.	26.476	Bronze tablet S.W. wing wall of R.R. bridge, Smithtown. Lat. = 40-51-30. Long. = 73-12-40.
SMITHTOWN	B104	20.460	Bolt root large oak W. side road 100' N. of brook crossing .9 mi. S.E. of Smithtown Lat. = 40-51-00. Long. = 73-13-32.

B.W.S. 473

PRIMARY CIRCUIT LEVELS (14)

LOCATION	B.M.	ELEV.	DESCRIPTION
SMITHTOWN	B105	43.962	Bolt root twin oak N. side rd. at fork rds. 3mi. E. Commack. Lat. 40-50-44. Long. 73-14-12.
W. HAUPPAUGE	B106	45.183	Bolt root oak E. side rd. 100' S. fork rds. 2½ mi. S.E. Smithtown. Lat. = 40-50-00. Long. = 73-14-10.
W. HAUPPAUGE	B107	61.203	Bolt root giant oak W. side rd. 150' N. fork of secondary rd. 2¾ mi. N. of Brentwood R.R. Sta. Lat. = 40-49-13. Long. = 73-14-00
BRENTWOOD	B108	143.973	Bolt root small twin oak S.W. intersection rds. 2 mi. N. of Brentwood. Lat. = 40-48-33. Long. = 73-14-30.
BRENTWOOD	B109	108.828	Bolt root pine E. side rd. at fork rds. 1mi. N. of Brentwood. Lat. = 40-47-33. Long. = 73-14-50.
BRENTWOOD	Geolg'l	88.319	Bronze tablet S.E. cor. Pres. Ch. 300' S. Brentwood R.R. Sta. Lat. = 40-46-48. Long. = 73-14-45.
BRENTWOOD	B110	76.375	Bolt root pine N.E. fork rds. ¾ mi. S. Brentwood R.R. Sta. Lat. = 40-46-08. Long. = 73-14-45.
BAY SHORE	B111	47.053	Bolt root young oak W. side Awixa Ave. 7000' N. R.R. track B.M. is near N. line of proposed street. Lat. = 40-44-56. Long. = 73-14-35.

B.W.S. 469

TABLE 60 (*Continued*)

PRIMARY CIRCUIT LEVELS (15)

LOCATION	B.M.	ELEV.	DESCRIPTION
COMMACK	B115	90.352	Bolt root oak N. side rd. at forks 2 mi. E. of Commack. Lat.: 40-50-45. Long.: 73-15-30.
COMMACK	B116	145.920	Bolt root large oak S. side rd. at forks 1 mi. E. of Commack. Lat.: 40-50-38. Long.: 73-16-40.
COMMACK	B117	134.686	Bolt root oak at inter. rds. 50' N.E. of Commack P.O. Lat.: 40-50-33. Long.: 73-17-33.
COMMACK	B118	164.932	Bolt root walnut W. side rd. 200' S. inter. rds. 1.1 mi. W. of Commack. Lat.: 40-50-20. Long.: 73-18-50.
COMMACK	B119	165.974	Bolt root chestnut N. side rd. 200' W. of forks 2.6 mi. W. of Commack. Lat.: 40-50-03. Long.: 73-20-13.
COMMACK	B120	269.565	Bolt root giant button ball tree S. side rd. at house of G. Carll. B.M. is at summit of rd. 3.2 mi. W. of Commack. Lat.: 40-49-50. Long.: 73-21-00.
MID. CO. ROAD	B121	196.342	Bolt root chestnut S.E. cor. forks 3¾ mi. W. of Commack and 4 mi. N.E. of Melville. Lat.: 40-49-53. Long.: 73-21-34.
MELVILLE	B122	170.305	Bolt root oak S. side rd. at forks 3.2 mi. N.E. of Melville. Lat.: 40-49-20. Long.: 73-24-27.
MELVILLE	B123	154.100	Bolt root small oak at house of G. Prohisky ¼ mi. S. inter. rds. 2 mi. N.E. of Melville. Lat.: 40-48-33. Long.: 73-23-23.
MELVILLE	B124	143.955	Bolt root giant oak N. side road 100' W. intersection of roads ¾ mi. E. of Melville. Lat.: 40-47-48. Long.: 73-24-18.
PINELAWN	B125	111.093	Bolt root oak N.W. cor. inter. rds. 2½ mi. N. Pinelawn R.R. Sta. Lat.: 40-46-57. Long.: 73-24-15.
PINELAWN	B126	97.411	Bolt root walnut W. side rd. 200' S. of 3 corners 1.8 mi. N. of Pine Lawn R.R. Sta. Lat.: 40-46-06. Long.: 73-24-20.

B.W.S. 471

PRIMARY CIRCUIT LEVELS (17)

LOCATION	B.M.	ELEV.	DESCRIPTION
EASTPORT	B150	59.028	Bolt root young oak 140' S. track 50' E. road crossing 1 mi. W. Eastport. Lat.: 40-49-42. Long.: 72-45-10.
EASTPORT	B151	73.268	Bolt root pine 25' E. track opp. whistle post 300' S. of P.E. of R.R. 2½ mi. N.W. Eastport R.R. Sta. Lat.: 40-49-55. Long.: 72-46-40.
E'PORT-MANOR R.R.	B152	83.109	Bolt root young oak 35' W. track and 12 rails S. rd. crossing 3 mi. S. Manor. Lat.: 40-50-25. Long.: 72-47-15.
SOUTH MANOR	B153	52.395	Bolt root oak 330' E. track and 150' S. ℄ rd. 1½ mi. S. of Manor. Lat.: 40-51-10. Long.: 72-47-23.
MANORVILLE	B154	60.696	Bolt root oak 120' W. track 300' N.W. fork rds. crossing R.R. ½ mi. S. of Manorville R.R. Sta. Lat.: 40-51-50. Long.: 72-47-52.
MANORVILLE	B164	47.078	Bolt root large willow 20' N. track 350' E. of Manorville R.R. Sta. Lat.: 40-52-32. Long.: 72-48-28.
MANORVILLE	B163	38.330	Bolt root pine 75' S. track and 11 rails W. rd. crossing 1 mi. E. Manorville. Lat.: 40-52-56. Long.: 72-47-35.
MANORVILLE	B162	42.130	Bolt root oak 120' N. track 200' N.W. R.R. crossing 1½ mi. E. Manorville. Lat.: 40-53-20. Long.: 72-46-55.
CALVERTON	B161	30.124	Knob S.W. abutment R.R. bridge over Peconic Cr. 1 mi. W. Calverton. Lat.: 40-54-08. Long.: 72-45-25.
CALVERTON	B160	38.932	Bolt root oak 150' S. track and 400' S.W. Calverton R.R. Sta. Lat.: 40-54-37. Long.: 72-44-48.
CALVERTON	B159	45.102	Bolt root oak E. side rd. 40' N. track. Rd. crossing 1 mi. E. of Calverton. Lat.: 40-54-55. Long.: 72-43-46.
MANORVILLE	B165	51.007	Bolt root twin oak 75' N.W. rd. crossing 1 mi. W. Manorville R.R. Sta. Lat.: 40-52-03. Long.: 72-49-28.
MANORVILLE	B166	48.677	Bolt root oak 30' S. track 450' W. rd. crossing 2½ mi. W. Manorville. Lat.: 40-51-33. Long.: 72-50-36.
YAPHANK	B167	66.252	Bolt root oak 40' S. track near telegraph pole #1665. B.M. 1000' N. of farmhouse. B.M. is 3 mi. E. of Yaphank. Lat.: 40-50-58. Long.: 72-51-56.
PINELAWN	B127	87.351	+ Cut top S. bolt at base water tower 500' S.W. Pinelawn R.R. Sta. B.M. is 2' above ground. Lat.: 40-44-39. Long.: 73-24-15.
PINELAWN	B128	66.058	Bolt 10" pine W. side rd. 25' N. forks 1½ mi. S. Pinelawn R.R. Sta. Lat.: 40-43-40. Long.: 73-23-51.
LINDENHURST	B129	45.966	R.R. spike base telegraph pole at N.W. cor. rd. crossing 1¼ mi. N. of Lindenhurst and 3½ mi. N.W. Babylon. B.M. is 30' S. of track. Lat.: 40-42-37. Long.: 73-23-03.
WEST BABYLON	B130	22.824	R.R. spike on N.W. cor. bridge over Santapogue Creek about 1 mi. N.W. inter. of R. rds. and 2 mi. N.W. Babylon. B.M. is 2' below rail. Lat.: 40-42-06. Long.: 73-21-38.

B.W.S. 483

TABLE 60 (*Concluded*)

PRIMARY CIRCUIT LEVELS (18)			
LOCATION	B.M.	ELEV.	DESCRIPTION
YAPHANK	B168	92.845	Bolt root large oak 40' S. track 125' E. rd. crossing 1¾ mi. E. Yaphank. Lat. = 40-50-26. Long. = 72-53-00.
YAPHANK	B169	50.412	Knob N.W. abutment highway bridge 1 mi. E. Yaphank. B.M. 6' below rail. Lat. = 40-49-57. Long. = 72-54-05.
WADING RIVER	B175	105.140	Bolt root oak N.W. cor. forks 1 mi. S. Wading River R.R. Sta. Lat. = 40-55-55. Long. = 72-50-13.
WADING RIVER	B177	118.133	Knob S.E. cor. culvert 1 mi. E. Wading River and 325' W. rd. crossing. Lat. = 40-56-41. Long. = 72-51-36.
WADING RIVER	B178	121.926	Bolt root chestnut 30' N. track, 250' N. rd. cross. 2 mi. W. Wading River. Lat. = 40-56-48. Long. = 72-52-50.
WARDENCLYFFE SHORAM	B179	135.471	Knob S.W. cor. h'way br. 1500' W. Shoram R.R. Sta. B.M. 21' below rail. Lat. = 40-57-00. Long. = 72-54-23.
ROCKY POINT	B180	160.582	Bolt root oak 15' N. Rocky Point R.R. Sta. Lat. = 40-57-02. Long. = 72-55-20.
ROCKY POINT	B181	131.452	Knob S.W. abutment br. 1 mi. W. Rocky Pt. Sta. B.M. 3' below rail. Lat. = 40-56-57. Long. = 72-56-33.
MILLER'S PLACE	B182	143.816	Knob S.W. cor. culvert 350' W. rd. crossing 1⅝ mi. E. Millers Pl. Sta. 4' bel. rl. Lat. = 40-56-50. Long. = 72-58-10.
MILLER'S PLACE	B183	151.717	Knob S.E. cor. foundation h'y br. 5' N. Rail 2000' E. Millers Place Station at rail elevation. Lat. = 40-56-40. Long. = 72-59-19.
PORT JEFFERSON	B184	159.024	Bolt root oak 35' S.E. rd. cr. 2 mi. E. Port Jefferson R.R. Sta. Lat. = 40-56-18. Long. = 73-00-50.
PORT JEFFERSON	B185	155.271	Knob N.E. cor. culvert 1000' E. rd. cr. 1 mi. E. Port Jefferson Sta. B.M. is 7½' below rail. Lat. = 40-56-02. Long. = 73-01-50.
WADING RIVER	B176	114.073	Bolt root oak E. side rd. 200' N. track and 250' N.E. Wading River R.R. Sta. Lat. = 40-56-40. Long. = 72-50-32.
PORT JEFFERSON	Geolg'l.	193.088	Bronze cap top pipe 6' W. of W. fence line; 8' N. track 250' W. Port Jefferson Sta. Lat. = 40-56-03. Long. = 73-03-10.
PORT JEFFERSON	B189	184.412	Bolt root oak E. side rd. 550' N. forks ⅝ mi. S. Port Jefferson Sta. Lat. = 40-55-48. Long. = 73-03-02.
PORT JEFFERSON	B190	155.286	Bolt root oak E. side rd. 500' S. forks 1⅝ mi. S.E. Port Jefferson Sta. Lat. = 40-55-07. Long. = 73-02-18.
PORT JEFFERSON — CORAM ROAD	B191	137.066	Bolt root oak 45' W. ℄ rd. 15' from edge of clearing and 300' S. of house 2⅝ mi. S.E. Port Jefferson Sta. Lat. = 40-54-18. Long. = 73-01-40.
CORAM	B192	102.477	Bolt root twin oak E. side rd. 40' N. forks 2 mi. N. Coram P.O. Lat. = 40-53-31. Long. = 73-01-00.

B.W.S. 486

TABLE 61

PRIMARY BENCH MARKS – BABYLON SECTION

LOCALITY	B.M.	ELEV.	DESCRIPTION ①
MELVILLE	B.205	143.493	B.W.S. Standard Precise Bench Mark, ¾ mile east of Melville, opposite B. 124, on south side of road about 100' W. of intersection of roads from Huntington, Farmingdale, & Melville. To replace B. 124.
BABYLON	B.206	13.878	B.W.S. Standard Precise Bench Mark, 20' west of south carriage entrance at Babylon R.R. Station, about 3ft. north of hedge on north side of Railroad Ave.
GREAT RIVER	B.207	6.173	Composition spike in southwest corner of R.R. bridge over Connetquot Brook, about 3' south of rail To replace B.M. B14

B.W.S. 395

PRECISE BENCH MARKS – PATCHOGUE SECTION

LOCALITY	B.M.	ELEV.	DESCRIPTION
PATCHOGUE	B193	14.194	B.W.S. standard B.M. in Patchogue R.R. yard 21.92' to fence post 6.22' to tack in water tank. 63.55' to stand pipe.
P. JEFFERSON	B194	192.589	B.W.S. standard B.M. about 250' W of Port Jefferson Sta. & about 17' N of R.R. track.
LAKE GROVE	B195	105.479	B.W.S. standard B.M. N.E. cor. intersection Rds. 3½ M N of Ronkonkoma R.R. Sta.
WESTHAMPTON	B196	45.833	B.W.S. standard B.M. at West end of Westhampton R.R. Sta. 18.51 to Tel. pole. 21.07' to tack in platform.
C. MORICHES	B197	26.377	B.W.S. standard B.M. on L.I.R.R. right of way. near int. of S.C. Rd. & R.R. 29.10 to Tel. pole # 1537 49.04' to signal pole 12.12 to forked tree.
RIDGE	B198	108.058	B.W.S. standard B.M. in front of Randolls house at int. of roads 2 M. E of Artist Lake
BLUE POINT	B199	24.846	Bolt in concrete in conc. coping of R.R. Bridge W abut. S.W. cor. about 2' above bridge seat 300' W of Blue Point Sta.
BROOKHAVEN	B200	20.599	Bolt in concrete on 3rd step of S.W. wing wall of R.R. bridge 800' West of Brookhaven R.R. Sta.
RIVERHEAD	B201	23.966	Bolt in concrete coping in N.W. corner of West abutment of railroad bridge ½ Mile West of Riverhead R.R. Sta.
CALVERTON	B202	30.182	Bolt 8" below bridge seat on S.W. cor. of West abut. of masonary R.R. bridge over Peconic Creek 1 Mile W of Calverton.
WD'NCLYFFE	B203	135.479	Bolt in S.W. cor. of coping stone in S.W. abutment of railroad bridge 150' W of Shoreham R.R. Sta. B.M. is 2.70' below rail.
YAPHANK	B204	51.513	B.W.S. standard B.M. S.W. cor. of int. of Yaphank & Middle Is. Rd. with main line L.I.R.R. 60.56' to Tel. pole # 1464 4[illegible] to Tel. Pole #[illegible]45 33.76 to Tel. Pole.

B.W.S. 449

TABLE 62

SECONDARY BENCH MARKS - BABYLON SECTION

LOCALITY	B.M.	ELEVATION	DESCRIPTION (1)
WEST BABYLON	U.S.G.S.	24.468	Spike N. side Tel pole 50 Ft S. of R.R. Crossing (Hempstead Branch) + 10 Ft E. of Albins
LINDENHURST	1	41.791	Spike N side Tel pole 40 Ft S. R.R. (Hempstead Br.) + 12 Ft W. of Wood Road
LINDENHURST	2	35.337	Highest Pt of Monument about 20 Ft from S.W. cor. Copaic, West Deerpark + Lindenhurst Rd.
LINDENHURST	3	33.889	Bent Copper Nail in W. side Cherry tree 25 Ft N of Square House + 30' E. of Rd. at N.E. cor. Copaic Rd. + Lindenhurst Cemetery Rd.
LINDENHURST	4	22.736	Copper nail in N.E. Side flag pole opposite Lindenhurst R.R. Station at S.W. cor. of Roads 100' S. of track + 2' W. of curb line
LINDENHURST	5	56.438	Wire nail in W. side of Tel pole about 15' from cor. of Copaic Babylon + Farmingdale Rds. 2½ miles N.W. of Lindenhurst R.R. Station
LINDENHURST	6	65.376	N.E. cor. of Mon. at S.E. cor. intersection on — Road + Pinelawn Rd.
LINDENHURST	7	45.520	Copper nail in W. side Tel pole at S.E. cor. of Farmingdale Rd. - Babylon - Lindenhurst - West Deer Park Rds.
BABYLON	8	30.86	Bolt in root, on E. side of 10" lone pine tree, 35' S. of Cy Udall Rd. & about 100' W. of house of C.F. Donner. Old B.M. El. 33.111 Destroyed.
BABYLON	9	28.651	Wire nail in apple tree 6' from N.E. cor. of Arnold Ave + Lane

B.W.S. 390

SECONDARY BENCH MARKS - BABYLON SECTION

LOCALITY	B.M.	ELEVATION	DESCRIPTION (2)
LINDENHURST	10	18.364	Wire nail in 2nd Tel pole N. of cor. of John St. (Humboldt Ave) + Albin Ave.
LINDENHURST	11	22.225	Wire nail in W. side of Tel pole at S.E. cor. of Humboldt Ave + — St. 1000' N. of R.R.
LINDENHURST	12	34.376	Wire nail in maple tree on S. side road. 50' W. of Fire Hall + 25. 500' E. of dug well #373 (Louis Herman)
LINDENHURST	13	44.637	Wire nail in small Pine at S.E. cor. of Road to St. Dominic Convent + Rd running E + W ½ mile S.E. of Convent + 1/4 mile N. of L#10
LINDENHURST	14	40.651	Wire nail in small pine N.E. cor. of W. Deer Park Lindenhurst Rd. + Rd. running E. + W. past B.M. #13
AMITYVILLE	15	18.034	Wire nail in root of Oak Tree at N.E. cor. of Oak St. + Road running N.
AMITYVILLE	16	30.367	Wire nail in root of — Tree 12' from N.E. cor. of County Line Rd. + Division Ave.
AMITYVILLE	17	39.500	Wire nail in root of Oak Tree on W. side road opposite cor. of Broadway + Harrison St. 10' from Rd. + 300' W. of T.W. No 5
AMITYVILLE	18	52.258	N.E. cor. of Mon. at N.W. cor. of Broadway + Great Neck Rd
AMITYVILLE	19	40.069	N.E. cor. of Mon. at S.W. cor. of Albany Ave. + Great Neck Rd 10' N.W. of L#6

B.W.S. 391

TABLE 62 (*Continued*)

SECONDARY BENCH MARKS - BABYLON SECTION (5)

LOCALITY	B.M.	ELEVATION	DESCRIPTION
AMITYVILLE	20	37.024	Wire nail in W. side of Fence Post at S.E. cor. of Albany Ave & Harrison St.
COPIAGUE	21	8.876	Wire nail in large Willow Tree at N.W. cor. of Merric Rd & Rd. to Copiague R.R. Station Near ○ #6
LINDENHURST	22	11.014	Wire nail in Tel. pole on S. side of Rd. opposite (△ Wellwood) the S.W. cor. of Merric Rd & Rd. to Lindenhurst
LINDENHURST	23	12.190	Wire nail in root of Oak Tree at S.E. cor. of Merric Rd & Rd. to Lindenhurst R.R. Station. Opposite ○ #8
BABYLON	24	9.041	Wire nail in root of Maple Tree at N.E. cor. of Merric & Great Neck Rds
BABYLON	25	14.665	Wire nail in E. side of Tel. pole 15' from the cor. of Merric & Little East Neck Rds
WEST ISLIP	26	39.206	Wire nail in root of large Oak Tree at cor. of Muncy's & Udall Rds
BAYSHORE	27	44.359	Wire nail in W. side of large Pine Tree at the N.E. cor. of Sagli Kos Manor Lane & Muncy's Rd. Opposite ∠ #41
BAYSHORE	28	33.471	Wire nail in small Oak Tree on E. side of Sagli Kos Manor Lane, 10' S.E. of ∠ #44
BAYSHORE	29	32.534	Wire nail in small Pine Tree on E. side of Sagli Kos Manor Lane & 40' N. of ∠ #176

B.W.S. 398

SECONDARY BENCH MARKS - BABYLON SECTION (4)

LOCALITY	B.M.	ELEVATION	DESCRIPTION
BAYSHORE	30	49.688	Wire nail in large Oak Tree on E. side of Bayshore Rd & near the cor. of Muncey's Rd. & Bayshore Rd. Opposite ∠ #43
BABYLON	31	13.859	Wire nail in Electric Light Pole on S. side of Rd. going N. & cor. of Park Ave
BABYLON	32	23.148	Wire nail in Tel. pole on W. side of Farmingdale Rd & opposite cor. of Park Ave
AMITYVILLE	33	46.187	Wire nail in S. side of Cherry Tree (200' S. of Convent) at N.W. cor. of Rd running past St Dominic Convent & Rd. going W.
AMITYVILLE	34	30.030	Wire nail in root of tree S.W. cor. of Albany Ave. & Rd. going W. to asylum. 2500 N. of R.R.
BAYSHORE	35	57.471	Spike in root of large pine 30' S of △ Keith
BAYSHORE	36	47.734	Spike in root of large pine on S. side of Muncey's Rd. 40' W. of Fire line clearing. 3/4 mile S. △ Keith
AMITYVILLE	37	49.003	Spike in root of Oak at N.E. cor. of Dixon & Bayview Aves.
COPAIGUE	38	30.416	Spike in root of Oak tree at N.E. cor. of Great Neck Rd. & Dixon Ave
COPAIGUE	39	38.859	Spike in pine tree at S.E. cor. of GREAT NECK RD. & rd. to Lindenhurst. About 1 mile N. of Copaigue R.R. Sta.

B.W.S. 399

TABLE 62 (*Continued*)

LOCALITY	B.M.	ELEVATION	DESCRIPTION (5)
COPAIGUE	40	36.837	N.E. cor. of S.M. (on N. side of Rd.) 1000' E. of intersection of Great Neck & Rd running W. from Lindenhurst.
COPAIGUE	41	33.940	Bent nail in sign post at N.E. cor. of Rd. to Lindenhurst & Rd. running N. & S. & opposite ⊙ 28
BABYLON	42	26.874	Spike in root of large Oak at S.E. cor. of rds. about 500' E. of S.W. cor. of Babylon Catholic Cemetery
BABYLON	43	28.573	N.W. cor. of S.M. at S.W. cor. of Deerpark Ave. & Rd. running W. & 500' S.W. of △ Cockerel
BABYLON	44	33.557	Spike in tel. pole at N.E. cor. of Deer Park Ave & Muncey's Rd.
BABYLON	45	31.410	Bolt in sign post at S.E. cor. of Muncey's Rd. & Higbie Ave.
BAYSHORE	46	56.365	Spike in pine tree at S.E. cor. of Sagtikos Manor Lane & Clearing. About 1 mile N. of Muncey's Lane
BAYSHORE	47	42.415	Spike in root pine tree at N.E. cor. of Muncey's Rd. & Wood Rd. W. of L-53
BAYSHORE	48	34.592	Nail mark on N.W. cor. of S.M. on N. side of Muncey's Rd. & W. end of clearing. 1000' W. of 5th Ave.
BAYSHORE	49	30.690	Spike in root of large Oak at S.E. cor. of Howells St. (Muncey's Rd) & 5th Ave.

B.W.S. 403

LOCATION	B.M.	ELEVATION	DESCRIPTION (6)
BAYSHORE	50	37.753	Spike in root of large Oak at S.W. cor. of 3rd Ave. & Islip Boulevard & opposite L-175
BAYSHORE	51	30.289	Spike in Maple tree at N.E. cor. Islip Boulevard & Brook Ave. & opposite Oakwood Stock Farm.
BAYSHORE	52	29.903	Spike in root of large Oak at N.W. cor. of Islip Boulevard & Brentwood Rd. Opposite Race Track
BAYSHORE	53	28.452	Bolt in root of oak at N.W. cor. of Islip & Saxon Boulevards
ISLIP	54	22.268	Spike in Pine at N.W. cor. of Islip Boulevard & Roman St.
ISLIP	55	22.649	Bolt in stump of Oak at S.W. cor. of Islip Boulevard & Nassau Ave.
ISLIP	56	28.349	Spike in root of Oak at S.W. cor. of Islip Boulevard & Islip Ave.
ISLIP	57	25.467	Spike in N. side of large Pine at S.E. cor. of Islip Ave & Rd. to the E. just N. of Islip Boulevard
ISLIP	58	31.332	Spike in large Pine on E. side of Islip Ave. ½ mile N. of Islip Boulevard & opposite △ 842
E. ISLIP	59	35.987	Bolt in tel. pole #I 1699 at cor. of Carlton Ave & Rd. running W. Just N. of Wagners Rd House

B.W.S. 402

SECONDARY BENCH MARKS - BABYLON SECTION

TABLE 62 (*Continued*)

SECONDARY BENCH MARKS – BABYLON SECTION

LOCALITY	B.M.	ELEVATION	DESCRIPTION (7)
E. ISLIP	60	29.730	Bolt in root of Wild Cherry on E. side of Carlton Ave & 50' N.E. of tel. pole #I 1678
BABYLON	61	24.305	Bolt in tel. pole #K.B. 116 at cor. of Deer Park Ave & Rd. running N. ½ mile N. of R.R. track
BABYLON	62	33.511	Bolt in root of large Oak on W. side of Deer Park Ave. & 75' S. of Rd. to Rod & Reel Club House
BABYLON	63	38.589	Bolt in root of large Willow on E. side of Deer Park Ave. opposite cor. of Rd. to Belmont & 300' S. of △ Housman
BABYLON	64	33.612	Bolt in Oak at S.W. cor. of Belmont Rd. & Wood Rd. running S. towards Rod & Reel Club
BABYLON	65	39.080	Bolt in root of large Oak on N. side of Belmont Rd. & opposite cor. of Rd. to Rod & Reel Club
BABYLON	66	40.158	Spike in root of Oak at the intersection of Rds 1000' N. of △ Belmont & 500' W. of Belmont's Pond
BABYLON	67	38.391	Nail in Maple on W. side of Belmont Ave. opposite S. end of Belmonts Race Track & 800' W. of △ Belmont
BABYLON	68	37.670	Bolt in small pine 30' from the N. side of Rd. & 1500' N.W. of L.[no] 178
BABYLON	69	43.856	Bolt in top of stump of small pine cut off about 2' from ground on E. side of Rd. & 500' N. of L.#27

B.W.S. 401

SECONDARY BENCH MARKS – BABYLON SECTION

LOCALITY	B.M.	ELEVATION	DESCRIPTION (8)
BABYLON	70	50.163	Bolt in E. side of Sign Post (30' E. of Rd.) at S.W. cor. of Clearing W. of Belmont Race Track
BABYLON	71	60.848	Bolt in top of 2' wood post at S.E. cor. of Lindenhurst-Wyandanch Rd & Belmonts Private Rd.
BABYLON	72	45.647	Bolt in root of large Pine at N.E. cor. of Belmont's Private Rd & Rd running N. to Wyandanch
BABYLON	73	35.950	Bolt in tall Pine 40' from E. side of Belmont Ave. & 500' N. of L.#28
BABYLON	74	35.684	Bolt in root of tall Pine on Belmont Ave. & 10' N. of N. end of brace of Belmont Terrace Sign
BABYLON	75	54.585	Bolt in top of stump of small pine (1½' high) 20' from W. side of Lindenhurst Wyandanch Rd & ½ mile N. of Babylon-Farmingdale Rd.
BABYLON	76	47.856	Bolt in small Pine at N.W. cor. of Lindenhurst Wyandanch Rd & Rd running N.W. Opposite L.#34
WYANDANCH	77	50.840	Bolt in root of large Oak on E. side of Rd. running toward Wyandanch on W. side of Belmont's Deer Park
WYANDANCH	78	59.230	Bolt in end post of N.W. cor. of Belmont's Deer Park on E. side of Rd. running from Belmont's Private Rd. to Wyandanch
WYANDANCH	79	64.901	Bolt in root of large Pine at intersection of Lindenhurst Wyandanch Rd. & Rd from Belmonts

B.W.S. 400

TABLE 62 (*Continued*)

LOCALITY	B.M.	ELEVATION	DESCRIPTION (9)
BABYLON	80	48.604	Bolt in root of large Locust at N.W. cor. of Deer Park Ave. & Rd. to Wyandanch
BABYLON	81	39.160	Bolt in Oak on S. side of Rd to Wyandanch, 1500' W. of Deer Park Ave. & 30' E. of △ #33
BABYLON	82	42.375	Bolt in large Pine 40' from S. side of road to Wyandanch & 300' E. of clearing & at bend in tree.
WYANDANCH	83	50.888	Bolt in small pine on N. side of Rd at intersection of Rd. to Wyandanch & Rd. running N. 4-45' E. of △ #32
WYANDANCH	84	50.823	Bolt in root of large Oak on N. side of the intersection of Rds. at E. end of Deer Park Lake.
BABYLON	85	41.977	Bolt in root of large Pine on N. side of Deer Park Ave. & cor. of Commac Rd.
BABYLON	86	59.698	Bolt in root of large Oak on W. side of Deer Park Ave. & 1000' S. of cor. of Half Hollows Rd.
BABYLON	87	62.283	N.E. cor. of S.M. at S.E. cor. of the intersection of Deer Park Ave. & Bayshore Rd.
DEER PARK	88	71.903	Bolt in top of 2" Wood property boundary post at the N.W. cor. of Deer Park Ave. & Grand Boulevard
DEER PARK	89	63.675	Bolt in top of wood property boundary post on N. side of Grand Boulevard & Rd. running N.

B.W.S. 435

LOCALITY	B.M.	ELEVATION	DESCRIPTION (10)
WYANDANCH	90	55.786	Bolt in root of large Pine on S. side of Rd. & 300' S.W. of WYANDANCH R.R. Sta.
WYANDANCH	91	63.210	Bolt in Belmont Sign Post at E. side of Lindenhurst-Wyandanch Rd. & 1500' N. of cor. of Belmont Private Rd.
PINE LAWN	92	55.077	Bolt in small Pine at N.E. of intersection of Rd. bounding Sheet Nine on the S. & Rd. running N.
PINE LAWN	93	65.263	Bolt in small Pine at E. end of clearing & 15' N. of Rd. which bounds Sheet Nine on the S.
PINE LAWN	94	69.280	Bolt in large Pine at W. side of Lindenhurst-Pine Lawn Rd. & 2000' N. of Goodman's B.M. (B 178)
PINE LAWN	95	74.917	Bolt in root of Pine on W. side of Neguntatogue Rd. & opposite A. Merritts house. ¼ mile S. of Pine Lawn R.R. Sta.
PINE LAWN	96	67.222	Bolt in Pine on W. side of East Neck Rd., 2500' N. of cor. of West Deer Park-Lindenhurst Rd. & 500' S. of White House.
PINE LAWN	97	67.009	Bolt in root of Pine on W. side of East Neck Rd. & 500' N. of White House
PINE LAWN	98	78.122	Bolt in root of Pine on W. side of East Neck Rd. & 50' S. of track
PINE LAWN	99	87.372	Bolt in small Oak at N.E. cor. of East Neck Rd. & Wood Rd.; 35' E. of △ 77 R & ½ mile N. of R.R. track.

B.W.S. 436

SECONDARY BENCH MARKS – BABYLON SECTION

SECONDARY BENCH MARKS – BABYLON SECTION

TABLE 62 (*Continued*)

LOCALITY	B.M.	ELEVATION	DESCRIPTION (11)
PINE LAWN	100	84.517	Bolt in root of large Pine on N. side of clearing + 300'E. of E. end of Green Lawn Cemetery
BABYLON	101	24.726	Bolt in base of Sign Post at cor. of Higbie Lane + Udell Rd. 1500'N. of track
BABYLON	102	29.073	N.E. cor. of S.M. at N.W. cor. of Higbie Ave + Lane running N-R 500'N. of intersection of Higbie Ave + Udell Rd.
BABYLON	103	23.882	Bolt in root of large Willow on W. side of Higbie Ave + 20'N. of ∠177
BABYLON	104	36.169	Bolt in root of large Oak on S. side of Muncie's Path + 200'W. of the intersection of Rd running N. to Housman's Farm
BABYLON	105	44.540	Bolt in root of Oak at S.E. cor. of intersection of Rds, 500' S. of Housman's Stock Barns + 30'N.W. of ∠ #57
BABYLON	106	54.247	Bolt in root of large Oak at S.E. cor. of Bay Shore Rd + Rd running S. past Houseman's Stock Farm
BABYLON	107	38.813	Bolt in Oak on S. side of Rd + 50'W. of cor. of Bayshore Rd. + Wicks Lane. About 200' W. of Wicks Pond
BABYLON	108	56.155	S.W. cor. of S.M. on E. of Bay Shore Rd + 800'N of cor. of Bay Shore Rd + Wicks Lane
BABYLON	109	51.738	Bolt in small pine at N.E. cor. of Bay Shore Rd + Commac Rd.

B.W.S. 406

LOCALITY	B.M.	ELEVATION	DESCRIPTION (12)
DEER PARK	110	72.237	Bolt in root of large Pine on W. side of Deer Park Ave + 30'S. of Centrall Line R.R. track
DEER PARK	111	78.678	Bolt in root of large Tree at S.W. cor. of Rd. running parallel to track (Indian Squaw St) + Carlls Straight Path.
DEER PARK	112	83.844	Bolt in root of Pine on W. side of Howell's Ave + 50'S. of track
EDGEWOOD	113	70.488	Bolt in small Pine at S.W. cor. of Howell Ave. + Wood Rd. running S. About 800' W. of large White House + ½ mile S. of R.R.
EDGEWOOD	114	57.030	Bolt in root of large Oak standing in open lot. 500'E. of White House + 100' S. of Howells Ave.
BAYSHORE	115	66.937	Bolt in root of large Pine 70' from the W. side of Rd. which passes △ Keith + ¾ mile N. of △ Keith
BABYLON	116	53.287	Bolt in root of large Oak on N side of Bayshore Rd. + 300'E. of Wicks Farm
BAYSHORE	117	61.659	Bolt in root of large Pine on W. side of Rd + ½ mile N. of Keiths Tower
BAYSHORE	118	26.544	Bolt in root of small Pine on E. side of Wood Rd. leading from S.M. No. 1 to ∠ 45
BAYSHORE	119	25.959	Bolt in root of Pine 30'W. of ∠ #45

B.W.S. 407

SECONDARY BENCH MARKS – BABYLON SECTION

TABLE 62 (*Continued*)

SECONDARY BENCH MARKS - BABYLON SECTION (13)

LOCALITY	B.M.	ELEVATION	DESCRIPTION
BAYSHORE	120	60.025	Bolt in root of Pine on E. side of Sagitkos Manor Lane & opposite $\angle$ #58
EDGEWOOD	121	68.968	Bolt in root of Pine on E. side of Manor Lane, 1 mile N. of Δ Thompson & 150' S. of Clearing
EDGEWOOD	122	75.736	Bolt in Pine on W. side of Manor Lane & 1 mile S. of Central Line Track
EDGEWOOD	123	93.938	R.R. spike in Pine on S. side of Deer Park Rd & 75' E. of cor. of Manor Lane: 100' S. of track.
EDGEWOOD	124	95.142	Bolt in root of Pine on S. side of Deer Park Rd. 200' E. of crossing of R.R. Siding & 100' S. of Central Line Track
BRENTWOOD	125	92.384	Bolt in root of Pine at S.E. cor. of Deer Park Rd & Old Telegraph Rd. 200' S. of track & 800' W. of R.R. Sta.
BRENTWOOD	126	79.122	Bolt in root of large Pine on E side of Old Telegraph Rd, in front of White House, 250' N. of Road House & ½ mile S. of track
BRENTWOOD	127	70.376	Bolt in root of Pine 40' from W. side of Old Telegraph Rd., 200' N. of White House & 3/4 mile S. of track
BAYSHORE	128	57.010	Bolt in root of large Pine 30' from the W. side of Old Telegraph Rd & 3000' N. of Rd. intersection
BAYSHORE	129	38.340	Bolt in root of large Pine at N.E. cor. of 5th Ave. & Rd running E. 1000' N. of Islip Boulevard

B.W.S. 404

SECONDARY BENCH MARKS - BABYLON SECTION (14)

LOCALITY	B.M.	ELEVATION	DESCRIPTION
BAYSHORE	130	32.061	R.R. spike in large Pine at S.E. cor. of intersection of Rds. & 200' W. of Δ White
BAYSHORE	131	41.859	Bolt in root of Oak at N.E. cor. of intersection of Rds. & 800' N.E. of Δ White.
BAYSHORE	132	52.535	Bolt in root of small Pine on E. side of Halsey St. & 1000' N. of $\angle$ #57
BAYSHORE	133	50.084	Bolt in root of large Pine on E. side of Halsey St & 1000' N. of $\angle$ #58
BAYSHORE	134	70.143	Bolt in root of small Pine on E. side of Halsey St & ½ mile N. of the cor. of Awixa Ave.
BRENTWOOD	135	65.109	Bolt in root of Pine on E. side of Awixa Ave. & ½ mile S. of the cor. of Sextons Rd
BAYSHORE	136	54.053	Bolt in root of Pine on E side of Awixa Ave., 30' S. of where bicycle path crosses Rd. & 1 mile S. of cor. of Saxton Ave.
BAYSHORE	137	37.563	S.W. cor. of S.M. on E side of Awixa Ave. & at N end of wire fence. 1000' N. of N end of Bayshore Race Track.
BAYSHORE	138	27.202	Bolt in root of Oak on W. side of Sexton Rd. & 500' N. of $\angle$ #73
BAYSHORE	139	33.002	R.R. spike in large Pine on E side of Saxton Rd, 100' N. of cor. of Rd. running N.E. & 300' S. of $\angle$ #75.

B.W.S. 405

TABLE 62 (*Continued*)

SECONDARY BENCH MARKS – BABYLON SECTION

LOCALITY	B M	ELEVATION	DESCRIPTION
BAYSHORE	140	35.493	R R spike in large Pine 100' N. of intersection of Sexton Rd. & Wood Rd. running W. 1200' S. of L #65.
BAYSHORE	141	50.509	Bolt in root of Pine 40' N. of L #66 & at N.E. cor. of Saxton Rd. & Wood Rd. running S.W.
BRENTWOOD	142	56.772	Bolt in root of large Pine on W. side of Sexton Rd. & 1/2 mile S.E. of cor of Awixa Ave.
BABYLON	143	30.497	N.W. cor. of S.M. on S. side of Muncys Path & 75' W. of cor. of Wood Rd. running S. to L #45.
BABYLON	144	41.583	Keil mark on S.E. cor. of S.M. on N side of Munceys Path, at W. edge of Clearing & 800' W. of Manor Lane.
W ISLIP	145	33.365	Wire nail in root of large Pine 150' N of Engine house at Experimental Pumping Sta
BAYSHORE	146	46.656	Bolt in side of 8" pine (150' N. of Test Well #54) on E. side of 1st wood road. E. of Hyde property and about 900 ft. N. of Muncy Rd. (Hunter's Ave.)
BAYSHORE	147	48.492	Bolt in root of 3" pine on E. side of 1st wood road E. of Hyde property and about 1500 ft. N. of Muncy Rd. (Hunter's Ave).
BAYSHORE	148	50.449	Bolt in side of 4" twin pines on W. side of 1st wood road E. of Hyde property, about 2300 ft. N. of Muncy Road (Hunter's Ave.) 30 ft. W. of Test Well # 55
BRENTWOOD	149	81.743	Bolt in root of 6" Oak about 3/4 mile East of Brentwood on road to Central Islip at S.W. Cor. of road intersection.

B.W.S. 408

SECONDARY BENCH MARKS – BABYLON SECTION

LOCALITY	B.M.	ELEV.	DESCRIPTION
CENT. ISLIP	150	90.586	Bolt in root of large pine, about 1 mile W. of Central Islip at N.E. Cor. of intersection of road from Islip to Brentwood, and road to Hauppauge.
CENT. ISLIP	151	81.161	Bolt in root of large pine about 3/4 mile W. of Central Islip on south side of road to Brentwood.
CENT. ISLIP	152	87.912	Bolt in root of 12" Chestnut on N. side of road to Brentwood about 1/4 mile W. of Central Islip.
CENT. ISLIP	153	87.875	Patchogue B.M. Bolt root large cherry tree, 40' N.E. of Central Islip Station.
CENT. ISLIP	154	69.885	L.I.B.M. #411. Nut on S.W. corner R.R. signal post, 3000' W. of Central Islip Station, N. of track.
CENT. ISLIP	155	52.632	Bolt at base of 10" White Oak 50 ft. S. of track and 25 ft W. of Wheeler Ave. about 1¼ miles E. of Central Islip R.R. Station.
CENT. ISLIP	156	44.356	Bolt S. side telegraph pole #859; 30' N. R.R.
CENT. ISLIP	157	47.366	Bolt top black and white post, 10' S. R.R. on culvert over Connetquot Brook.
CENT. ISLIP	158	71.288	Bolt N.E. base 18" oak, 30' S. R.R. 100' W. of Oxhead Road.
CENT. ISLIP	159	42.030	Nail root pine at inter. of roads 1/2 mi. N. R.R. and 3¼ mi. E. of Central Islip Station. B.M. is 50' W. of intersection.

B.W.S. 409

TABLE 62 (*Concluded*)

LOCALITY	B.M.	ELEV.	DESCRIPTION (17)
CENT. ISLIP	160	51.185	Nail root pine 25" N. angle in road 3½ mi. E. of Central Islip Station and 1 mi. N. of track. B.M. is at intersection of secondary road opposite red building.
CENT. ISLIP	161	68.956	Nail root 12" locust, intersection of fences and opposite inter. of roads. 2 mi. W. Ronkonkoma Lake and midway between Country Road and R.R.
HAUPPAUGUE	162	52.986	Nail root small oak on E. side of intersection of roads 1½ mi. S.W. of Ronkonkoma Lake and ½ mi. S. of Country Road.
HAUPPAUGUE	163	59.739	Nail root 14" cherry at intersection of roads half way between Lake Ronkonkoma and Hauppauge and ½ mi. S. of Country Road.
HAUPPAUGUE	164	59.280	Nail root 10" oak at cross roads ½ way between Lake Ronkonkoma and Hauppauge. B.M. is 75' south of intersection and on W. side of road.
SMITHTOWN BRANCH	165	55.560	Nail root giant walnut tree on S. side of main road, 1½ mi. E. of Hauppauge. B.M. is 200' E. of cross roads.
SMITHTOWN BRANCH	166	69.984	Bolt root 10" locust in N.E. angle of roads at Hauppauge B.M. is inside of fence 10' E. of gate.
SMITHTOWN BRANCH	167	64.287	Head nail in giant oak on W. side road from Smithtown Branch to Hauppauge, and about ½ mi. N. of Hauppauge B.M. is 35' W. of road.
SMITHTOWN BRANCH	168	74.131	Head nail in small oak on E. side road from Smithtown Branch to Hauppauge. B.M. is about 15' N. of inter. of road to E. and about half way bet. Smithtown Br. and Hauppauge
SMITHTOWN BRANCH	169	60.765	Nail knob root giant oak 100' N. intersection of road ½ mi. South of Smithtown Branch, on road from Smithtown Branch to Hauppauge.

SECONDARY B.M'S. BABYLON SECTION

B.W.S. 484

LOCALITY	B.M.	ELEV.	DESCRIPTION (18)
GREAT RIVER	170	33.404	Bolt in root of 12" Pine 23' N. of B 24 K
BABYLON	171	6.673	N.E. Cor. of stone Monument at S.W. Cor. of Main & Thompson Sts.
BABYLON	172	4.869	N.E. Cor. of stone Monument at N.W. Cor of Thompson and Reid Aves.
BABYLON	173	2.815	Bolt in bulkhead 2' from top. at Tide Gage in West Creek at Searles boat house
GREAT RIVER	174	15.10	Nail in root of pine tree, flush with ground, 84' E. of B 27 SA on Traverse Line.
W. ISLIP	175	11.360	Nail in 3" Oak on E. side of Higbee Ave. 200 ft. N. of South Country Road.
W. ISLIP	176	10.247	Bolt in root of 20" Oak on S. side of South Country Road opposite 1st road E. of Wagstaff's Pond.
BAYSHORE	177	12.341	Bolt in root of 2" Hickory tree - 7th. tree E. of Manor Lane on South Country Road.
BAYSHORE	178	8.291	Bolt in root on N. side of tree. W. of Park Ave. N Side of South Country Road.
BAYSHORE	179	14.526	Nail in Tel. Pole No 1-186, 1 ft. above ground, east of Awixa Ave on South Country Road.
ISLIP	180	22.742	Nail in S. side Tel. Pole I-268, on S. side South Country Road, 1 ft. above ground, near Carleton Ave.
ISLIP	181	14.258	Nail in north side of Tel. Pole I-236 on south side of South Country Road, near Nassau Ave.
ISLIP	182	12.530	Nail in root of 2" tree on northwest corner of Saxon Ave. & South Country Road.

SECONDARY B.M'S BABYLON SECTION

B.W.S. 485

TABLE 63

SECONDARY BENCH MARKS - PATCHOGUE SECTION

LOCALITY	B.M.	ELEVATION	DESCRIPTION ①
Patchogue	201	26.727	N. Nut, Fire Hydrant cap, S.W. Cor. Ocean Ave. & Cedar Grove Ave.
"	202	41.390	Head of Nail in root of Oak tree, opp. corn Field, 100 Ft. North of road on S. Side Field, ± 3/4 mile N. of Roe Ave.
"	203	48.020	Nail in Pine tree, W. side of road
"	204	54.600	Nail in Pine tree 40 Ft. W. intersection N. Ocean Ave. and Cross road
"	205	56.210	Nail in Pine tree, E. of road
"	206	53.170	Nail in Pine tree, E. of road
Holtsville	207	80.470	Nail in Pine tree, W. of road about 300 Ft. S. of L.I.R.R. Main Line, E. of Holtsville
"	208	100.530	Nail in Pine tree, W. side Spencer Ave. cor. S.W. road to Waverly Ave.
"	209	87.830	R.R. spike in Pine tree, 60 Ft. W. of Spencer Ave.
"	210	65.690	Spike in Pine tree, W. of Spencer Ave.

U.S.C.&G. Datum

B.W.S. 385

SECONDARY BENCH MARKS - PATCHOGUE SECTION

LOCALITY	B.M.	ELEVATION	DESCRIPTION ②
Holtsville	211	61.670	Nail in Pine tree W. of Spencer Ave.
Blue Point	212	51.110	R.R. Spike in Pine tree ± 400 Ft. S. of cross-road. W. of Spencer Ave.
"	213	41.197	R.R. Spike in Pine tree S.E. Cor. Spencer Ave. & Blue Point Road
"	214	32.690	Nail in Pine, E. Side Spencer Ave. 1200 Ft. S. of Blue Point Road.
Bayport	215	25.650	Tack in Oak tree S.E. cor. Broadway Ave & Burger Ave.
"	216	41.140	R.R. Spike in Pine tree, W. side Broadway Ave. S. of Blue Point Road
"	217	59.490	R.R. Spike in Pine tree N.E. Cor. Broadway Ave. & Road E.
Holbrook	218	79.465	R.R. Spike in Oak tree, E. side Broadway Ave.
"	219	92.551	R.R. Spike in Oak tree, E. side Broadway Ave. 1/4 mile S. of intersection Lake Ave.
"	220	104.308	Nail in Root of large Oak 300 Ft. S of Holbrook School House, E side Lake Road

U.S.C.&G. Datum

B.W.S. 384

TABLE 63 (*Continued*)

SECONDARY BENCH MARKS - PATCHOGUE SECTION

③

LOCALITY	B.M.	ELEVATION	DESCRIPTION
Holbrook	221	97.730	R.R. Spike in Tel. pole No. 1089 N. of L.I.R.R. Main Line
"	222	115.667	R.R. Spike in Maple tree, N. of L.I.R.R. 30 Ft. West of Station
"	223	103.742	R.R. Spike in Pine tree W. of Bedell Road, 100 Ft. S. of L.I.R.R. track
Ronkonkoma	224	88.582	R.R. Spike in Pine Stump 125 Ft. S. Intersection of Bedell Road & Smithtown Ave.
Bohemia	225	74.889	R.R. Spike in Oak Tree 200 Ft S. of intersection of Lakeland Ave. & Bohemia Road.
"	226	60.164	R.R. Spike in Tel. pole 12181 W. Side Lakeland Ave. 300 Ft. S. of Church St.
"	227	35.824	R.R. Spike in Pine Tree, W. side Lakeland Ave. 50 Ft S. of Tel. pole 12136
Patchogue	228	16.310	R.R. Spike in Tel. pole 100 Ft. E. of Ocean Ave. N side L.I.R.R. track.
"	229	14.727	R.R. Spike in Oak Tree N.W. cor. Bay Ave at L.I.R.R.
"	230	23.151	Nail in Oak Tree, W. side Medford Ave. 100 Ft. N. of Northridge St.

B.W.S. 497

SECONDARY BENCH MARKS - PATCHOGUE SECTION

④

LOCALITY	B.M.	ELEVATION	DESCRIPTION
Patchogue	231	49.140	R.R. Spike in Pine Tree, edge of woods, at intersection of Medford Ave. & Coram Road
"	232	63.490	R.R. Spike in Pine Tree, E. side Medford Ave.
Medford	233	82.730	Nail in Pine tree, E. of Medford Ave. 100 Ft. E. and S. Side Peconic Ave.
"	234	88.480	R.R. Spike in large Ash Tree, Medford Road, 100 Ft. N. of L.I.R.R. track.
E. Patchogue	235	13.953	Top of Drift-bolt, top stick, W. abutment L.I.R.R bridge Swan River, at angle of Wing, S. Side.
"	236	20.710	Nail in 2nd. tel. pole E. of Mud Creek Fill, S. side L.I.R.R.
"	237	23.068	Nail in Root of Pine Tree, intersection of Middle Island and Yaphank Roads.
"	238	25.000	Nail in root of Oak, W. Side Middle Island Road at N. edge of clearing.
"	239	33.490	Top of Cap, Well 201
"	240	38.037	Nail in root of small Oak, E. Side trail 250 Ft. E. of White house on Barton Ave.

B.W.S. 480

TABLE 63 (*Continued*)

SECONDARY BENCH MARKS - PATCHOGUE SECTION (5)

LOCALITY	B.M.	ELEVATION	DESCRIPTION
E. Patchogue	241	48.165	Top of Cap, Well 202 Cor. Barton Ave.
Patchogue	242	56.936	Top of Cap, Well 211 on Barton Ave, E. of Medford Ave
"	243	44.240	R.R. Spike in Pine Tree E. of Trail, S. of Barton Ave.
"	244	35.241	Top of Cap. Well 236
"	245	27.772	Nail in Pine Tree E. of Medford Ave. on Trail
Hagerman	246	15.613	Top of cap, Well 234, Dunton Ave. S. of L.I.R.R.
"	247	15.800	Nail in root of Oak Tree, 15 Ft. W. of Dunton Ave.
"	248	27.054	Top of Cap, Well 235, E. of Dunton Ave.
"	249	37.338	Nail in Danger Signal on Dunton Ave. & L.I.R.R.
Sayville	250	35.521	R.R. Spike in Pine Tree, edge of woods, 2000 Ft. N. of int. Lakeland & Moscow Ave's.

B.W.S. 478

SECONDARY BENCH MARKS - PATCHOGUE SECTION (6)

LOCALITY	B.M.	ELEVATION	DESCRIPTION
Sayville	251	31.276	R.R. Spike in Pine Tree 100 Ft. N. of intersection Lakeland and Moscow Ave's. W. side.
Hagerman	252	19.983	Top of Cap. Well 229 Cor. Taylor Ave.
Bellport	253	31.607	Top of cap, Well 230
Hagerman	254	44.405	N.E. Cor. Dunton Road
"	255	50.946	Top of cap, Well 244 ½ mile E. of Dunton Road
"	256	24.145	Top of cap, Well 233, 1000 Ft. W. of Dunton Road
"	257	39.318	Top of cap, Well 203 on N.W. Trail W. of Dunton Ave.
"	258	57.580	Top of Cap, Well 204, Cor. Dunton & Barton Ave's.
"	259	52.521	Top of cap, Well 205, ¼ mile E. of Dunton Ave. and on Road N. of Barton Ave.
"	260	41.362	Top of cap, Well 231 W. of Bellport Sta. L.I.R.R.

B.W.S. 479

TABLE 63 (*Continued*)

LOCALITY	B.M.	ELEVATION	DESCRIPTION ⑦
Patchogue	261	27.516	R.R. spike in tel. pole B.H. 2930 N.W. Cor. Roe and Ocean Aves.
"	262	29.389	Nail in root of Oak Tree, Roe Ave. opposite West end of clearing.
"	263	11.886	Nail in crib log N.E. Cor. bridge, Roe Ave. Lace Mill Pond
"	264	12.275	R.R. Spike in small tree at edge of stream at site of proposed Weir, E. Branch Patchogue Creek.
"	265	39.198	Nail in root triple oak tree W. side Ocean Ave at N. edge clearing, opp. small road to E
Sayville	266	15.529	N.E. Cor. S. door Sill Electric Light Sta. 1000 Ft. West of Sayville Station, L.I.R.R.
"	267	30.265	Bolt in root small Oak Tree, N.E. Cor. R.R. and road, 60 Ft. N. of track, 1000 Ft W. of B.M. 266
"	268	30.520	Top of cap, Well 123, N. of R.R.
"	269	33.018	Bolt in top of E. Rail Rest, opp. Mile post 49 L.I.R.R.
"	270	33.239	Top of cap, Well 122, opp. F.G. Bourne's siding

B.W.S. 476

SECONDARY BENCH MARKS - PATCHOGUE SECTION

LOCALITY	B.M.	ELEVATION	DESCRIPTION ⑧
Sayville	271	27.374	Bolt S.E. Cor. Foundation of Semaphore opp. Tel. pole 1985
"	272	24.603	Top of Cap. Well 121
Patchogue	273	45.710	Bolt in Twin Oak in Pine woods, partly cleared, 150 ft. E. of ⊡ 356D
Sayville	274	31.767	Bolt in root of Oak Tree, W. side of road at trail to N.W. about 800 Ft. N. of R.R.
"	275	6.248	Nail in root of twin Willow Tree, N. side South Country Road 700 ft. W. of Roosevelt bridge
Patchogue	276	26.072	Top of Pipe, Well 182 (No. cap on) N. 43,823.1 E. 269,642.6
Oakdale	277	15.981	Top of cap, Well 117, W. Side road to Oakdale Station N. of R.R.
"	278	12.718	Bolt N.E. Cor. Semaphore No. 475, 200 ft. E. of Oakdale Sta.
Hagerman	279	34.725	Top of cap, Well 184 N. 39,698.6 E. 275,710.3
Oakdale	280	43.329	Bolt in stump of small Pine Tree, at int. of trail with Bourne's Road

B.W.S. 477

SECONDARY BENCH MARKS - PATCHOGUE SECTION

TABLE 63 (*Continued*)

SECONDARY BENCH MARKS - PATCHOGUE SECTION

⑨

LOCALITY	B.M.	ELEVATION	DESCRIPTION
Oakdale	281	49.945	Bolt in stump of small pine, E. Side of trail
"	282	41.217	Top of Cap, Well 118
"	283	50.905	Bolt in stump of small Pine, Bourne's Road
"	284	49.648	Top of Cap, Well 115 Pond Road
"	285	12.837	Top of Cap, Well 116 Pond Road
"	286	13.751	Bolt in stump of small Pine, back of Well 118 N. 28,932 E. 235,346
"	287	30.037	Top of Cap, Well 119
Patchogue	288	35.899	Top of Cap, Well 149, Waverly Ave.
"	289	42.451	Top of Cap, Well 168, Waverly Ave. N. 40,022 E. 259,214
"	290	38.332	Top of Cap, Well 150, Waverly Ave.

B.W.S. 452

SECONDARY BENCH MARKS - PATCHOGUE SECTION

⑩

LOCALITY	B.M.	ELEVATION	DESCRIPTION
N. Hagerman	291	62.505	Bolt in stump of small Pine
"	292	70.114	Top of Cap, Well 221
"	293	67.502	Bolt in stump of small Pine, S.E. Cor. Dunton Road and cross road
"	294	59.652	Top of Cap, Well 206
"	295	59.688	Top of Cap, Well 294
Bellport	296	64.280	Bolt in stump of small Pine on Barton Ave. 400' W. of Trail
"	297	66.342	Bolt in Pine stump 30' S. of int. Barton and Bellport Ave's. E. Side.
"	298	59.097	Top of Cap, Well 292
S. Medford	299	42.214	Top of Cap, Well 295
"	300	44.020	Bolt in stump E. side of road, 40' N. of Well 295

B.W.S. 453

TABLE 63 (*Continued*)

LOCALITY	B.M.	ELEVATION	DESCRIPTION (11)
S. Medford	301	58.262	Top of Cap, Well 208
"	302	66.718	Bolt in stump S. side trail, 200' E. of Well 208
"	303	81.926	Bolt in stump
S. Plainfield	304	79.400	Top of Cap, Well 207
Patchogue	305	46.465	Bolt in Cedar Tree 150' W. Medford Ave.
"	306	48.687	Top of Cap, Well 160
"	307	38.294	Top of Cap, Well 165
"	308	39.405	Top of Cap, Well 158
"	309	61.599	Top of Cap, Well 161
"	310	71.173	Bolt in stump of Pine Tree 500' N. of B.M. 232 E. side of Ave.

B.W.S. 422

SECONDARY BENCH MARKS - PATCHOGUE SECTION

LOCALITY	B.M.	ELEVATION	DESCRIPTION (12)
Medford	311	71.489	Top of Cap, Well 162
"	312	63.774	Top of Cap, Well 163
"	313	81.058	N.E. edge, E. abutment concrete highway bridge ¾ mile W. of Medford R.R. Station
"	314	82.217	Bolt in W. rail rest opp. Mile post marked 55-40 about ¼ m. E. of Medford R.R. Station
Plainfield	315	82.570	Bolt in root of Oak Tree ½ m. W. of Plainfield Sta. 50' S. of Track N. of group of outhouses in hollow.
"	316	102.557	Bolt in small Pine stump 250' S. of L.I.R.R. track on W. side of trail
"	317	98.216	Top of cap, Well 224
"	318	63.573	Top of Cap, Well 210
"	319	105.109	S.W. Cor. Concrete foundation of L.I.R.R. Exp. Ag'l. Sta. tank Plainfield △
Patchogue	320	26.334	Top of Cap, Well 159

B.W.S. 423

SECONDARY BENCH MARKS - PATCHOGUE SECTION

TABLE 63 (*Continued*)

SECONDARY BENCH MARKS - PATCHOGUE SECTION (13)

LOCALITY	B.M.	ELEVATION	DESCRIPTION
Medford	321	80.026	Top of Cap, Well 209
Holtsville	321a	63.771	Bolt in small Pine stump
"	322	47.504	Top of Cap, Well 155
"	323	48.349	Top of Cap, Well 156
Patchogue	324	22.898	Bolt in root of Oak Tree, S.E. Cor of Trail running South
"	325	54.024	Top of Cap, Well 164
Gt. River	326	57.412	Bolt in root of small Oak 100' N.W. of intersection of trails.
"	327	26.852	N.W. bolt Semaphore #455 Foundation, 1000' East of Gt. River R.R. Station
"	328	21.162	Top of Cap, Well 91
"	329	23.135	Bolt in root of Oak Tree, 100 Ft. W of Well 91

B.W.S. 433

SECONDARY BENCH MARKS - PATCHOGUE SECTION (14)

LOCALITY	B.M	ELEVATION	DESCRIPTION
Gt. River	330	20.133	Bolt in crotch of double Oak Tree, 50 Ft W. of Well 95
"	331	15.292	Top of Cap; Well 92
"	332	19.928	Top of Cap, Well 95
"	333	34.885	Bolt in stump of small Oak, 1000 Ft. S. of Well 92 on W. side of trail.
"	334	25.569	Bolt in stump of 3" Pine 1500' N. of Well 92
"	335	40.188	Bolt in stump of 3" Oak at intersection of road and trail, 20 Ft. E. of Well 1186
"	336	45.860	R.R Spike in large Pine Tree
Cen. Islip	337	45.320	Top of Cap, Well 96
"	338	49.050	Top of Cap, Well 100
Patchogue	339	19.771	Top of Cap, Well 157

B.W.S. 434

TABLE 63 (Continued)

LOCALITY	B.M.	ELEVATION	DESCRIPTION
Hagerman	340	31.843	Top of Cap Well 63 [illegible]
"	341	28.433	[illegible]
Patchogue	342	64.786	Top of Cap Well 54
Blue Point	343	40.587	Top of Cap Well 46
"	344	51.832	Top of Cap Well 44
"	345	53.534	Bolt in small Oak stump at intersection of [illegible] and Spencer Ave.
"	346	57.664	Top of Cap. Well 184
E. Islip	347	20.535	Top of Cap Well 85
"	348	25.020	Top of Cap, Well 86
"	349	33.250	Top of Cap. Well 830

B.W.S. 437

SECONDARY BENCH MARKS PATCHOGUE SECTION

LOCALITY	B.M.	ELEVATION	DESCRIPTION
E. Islip	350	31.445	Top of Cap, Well 93
"	351	32.786	Bolt in root of Pine Tree 1000 ft S of [illegible] Carlton Ave. opp. trail running E
Cen. Islip	352	34.780	Top of Cap, Well 98
"	353	57.671	R.R. Spike in tel pole [illegible] opp gate
Patchogue	354	13.115	R.R. Spike in Oak Tree, [illegible] N of BM 264 on E bank of stream
"	355	13.951	Bolt in Oak Tree 700' N. of BM 264 [illegible]
Cen. Islip	356	68.435	Top of Cap, Well 99
"	357	86.155	Bolt in root of large Birch Tree, [illegible] E of R.R. Station at Central Islip, 25 ft N of track
"	358	70.480	Top of Cap, Well 102
"	359	52.437	Top of Cap, Well 101

B.W.S. 438

SECONDARY BENCH MARKS - PATCHOGUE SECTION

TABLE 63 (*Continued*)

LOCALITY	B.M.	ELEVATION	DESCRIPTION (17)
Cen. Islip	360	50.285	Bolt in root of Pine Tree 500 Ft. S. of Ballground, on East side of trail.
Gt. River	361	21.204	Top of Cap, Well 97
"	362	28.002	Bolt in root of Pine Tree, W. side of trail, 1500 Ft. N. of Well 97
"	363	30.935	Bolt in Pine Tree, W. side of trail, 50 Ft. S. of Well 90
"	364	31.017	Top of Cap, Well 90
"	365	25.430	Top of Nut S.W. Cor. Semaphore Foundation #448, 1000 Ft. W. of Well 97
"	366	24.911	Top of Cap, Well 89
"	367	25.345	S.E. Bolt Semaphore #442 Foundation, 1200 Ft. East of B.M. B 11
"	368	23.639	Bolt in large Oak, N.W. cor. River
"	369	21.824	Top of Cap, Well 1086

SECONDARY BENCH MARKS - PATCHOGUE SECTION

B.W.S. 425

LOCALITY	B.M.	ELEVATION	DESCRIPTION (18)
Gt. River	370	22.048	Bolt in root of Oak Tree, S.E. Cor. of cross roads
"	371	19.899	Bolt in root of Oak Tree
"	372	14.767	Top of Cap, Well 88
"	373	15.098	Staple in root of Oak Tree 5 Ft. E. of Well 88
E. Islip	374	13.310	Staple in root of Oak Tree, S. side of Trail
"	375	16.611	Top of Cap, Well 87
"	376	17.168	Staple in large Oak, 50 Ft. N. of Well 87, E. side of road
Sayville	377	25.318	Bolt in root of large Oak, W. side trail, 1000' N of L.I. R.R.
"	378	30.703	Top of Cap, Well 60
"	379	22.097	Bolt in stump of Oak Tree 1200 Ft. N.W. of Well 60, N. side of trail

SECONDARY BENCH MARKS - PATCHOGUE SECTION

B.W.S. 426

TABLE 63 (*Continued*)

LOCALITY	B.M.	ELEVATION	DESCRIPTION (19)
Sayville	380	29.448	Bolt in root of large Pine, 1200 Ft. W. of Well 60 N. side of trail.
"	381	40.782	Bolt in Pine stump 40 Ft. N. of Well 1198
"	382	39.697	Top of Cap, Well 1198
"	383	42.533	N. Cor. Top of Monument at intersection of Smithtown Road & Bourne's Fire line. S.E. Cor.
"	384	48.788	Top of Cap, Well 120 N. 31.279 E. 238.479
"	385	50.453	S.E. Cor. Monument at intersection of trail with Smithtown Road
"	386	48.358	N.W. Cor. Top of Monument at intersection of Smithtown Road and Bourne's Fire line
"	387	50.341	S.W. Cor. Blue-stone Monument opp. new house and on trail running W.
Patchogue	388	31.327	Top of Cap, Well 1145, N. Ocean Ave. W. side, S. of Roe Ave.
Islip	389	28.023	Bolt in root of large Oak 800' N. of well 86, on E. side of Carlton Ave. 50 Ft. N. of Tel. pole I-1678

B.W.S. 410

SECONDARY BENCH MARKS - PATCHOGUE SECTION

LOCALITY	B.M.	ELEVATION	DESCRIPTION (20)
Hollsville	390	105.806	Bolt in stump of small Oak 30 Ft. W. of Primary Tower near Fence.
Ronkonkoma	391	101.128	Bolt in root of Buttonwood Tree 100 Ft. E. of House used as Primary △, 50' N. of Track
Cen. Islip	392	78.428	Bolt in root of Maple Tree, E. Side Carlton Ave. 40 ft. N. of R.C. Church, Primary △
Bohemia	393	63.333	S.E. Cor. Stone Monument, S.E. Cor. Smithtown Road and Church St.
"	394	75.045	Bolt in stump on tree 25 Ft. N.W. of N.W. cor. barn at int. of Lakeland Ave. and Smithtown Road
"	395	80.788	Top of Cap, Well 132
"	396	81.679	Bolt in small Pine stump 150 Ft. W. of Well 132 on the Wheeler Road.
"	397	82.081	Bolt in crotch of double Oak Tree S.W. cor. Lakeland Ave. and Wheeler Road
"	398	80.290	S.E. cor. White marble Monument 28 Ft. N. of Road sign, at int. of Wheeler Road and Road to Sayville & Oakdale
"	399	81.677	Top of Cap, Well 1200

B.W.S. 411

SECONDARY BENCH MARKS - PATCHOGUE SECTION

TABLE 63 (*Continued*)

LOCALITY	B.M.	ELEVATION	DESCRIPTION (21)
Bohemia	400	74.162	Bolt in small Pine stump, edge of woods, 600' W. of white house & 100 N. of trail running N.W.
"	401	68.397	Top of Cap, Well 114
"	402	80.051	Bolt in root of Pine, S. Side Wheeler Road
"	403	80.858	Top of Cap, Well 113
"	404	54.180	Top of Cap, Well 112
Sayville	405	27.127	Bolt in root of large Pine, 300' N. of R.R. E. Side of trail
"	406	52.616	Bolt in Forked Oak, Road E. of Pond Road, at int. fire line and old trail
Ronkonkoma	407	40.877	Top of Cap, Well 110
"	408	46.507	Bolt in root of Oak Tree, 200' S.E. of R.R. N. side Wheeler Rd
"	409	53.308	Bolt in root of large Oak, 40' S of R.R. 75' W. of Wheeler Road

SECONDARY BENCH MARKS - PATCHOGUE SECTION

B.W.S. 412

LOCALITY	B.M.	ELEVATION	DESCRIPTION (22)
Cen. Islip	410	62.426	Top of Cap, Well 106
"	411	68.149	Top of nut S.W. Cor. Semophore #438, 300' E. of Well 102
"	412	37.919	Top of Cap, Well 107
"	413	39.432	Bolt in Oak stump at intersection of trail & fire line
Gt. River	414	28.944	N.E. Cor. N.E. foundation, Cutting's Wind Mill, Primary Δ
Cen. Islip	415	38.757	Bolt in root of Oak Tree 300' N.W. of Well 110 in middle of trail, S. Side wire fence.
"	416	40.852	Top of Cap, Well 109
Ronkonkoma	417	46.489	Top of Cap, Well 111
N. Blue Pt.	418	64.194	Top of Cap, Well 143
"	419	64.755	Top of Cap, Well 1007

SECONDARY BENCH MARKS - PATCHOGUE SECTION

B.W.S. 413

TABLE 63 (*Continued*)

LOCALITY	B.M.	ELEVATION	DESCRIPTION (23)
Blue Point	420	38.362	Bolt in root of Oak Tree. 150 ft S of intersection of Roads
"	421	36.963	Top of Cap. Well 147
"	422	35.531	Top of Cap. Well 148
"	423	43.316	Bolt in Oak Tree, 2000' W. of B.M 213 & 50' S of intersection with trail running South.
"	424	31.189	Top of Cap. Well 188 N. 34,070 E. 253,146
"	425	29.605	Top of Cap. Well 138
"	426	29.719	Bolt in root of Oak Tree, 200' S of Well 138, W. side of trail
"	427	38.871	Bolt in root of small Oak, at triangle formed by trails
"	428	43.842	Bolt in root of small Oak, between two blazed trees, 40' S. of Wheeler Road, 160' N of Well 139
"	429	43.627	Top of Cap. Well 139 N. 36,624 E. 254,929

B.W.S. 414

LOCALITY	B.M.	ELEVATION	DESCRIPTION (24)
Sayville	430	24.700	C. of stone boundary mon. at fence post between two small houses E. of red mill, ¼ m. W. of Broadway Ave. on North Road
"	431	23.474	Top of Cap, Well 137
"	432	37.926	Top of Cap, Well 169
"	433	37.855	Top of Cap, Well 136
"	434	41.398	Top of Cap, Well 173
"	435	42.450	Top of Cap, Well 135
"	436	69.017	Bolt in root of Oak Tree 30' N. of road leading to house on E. side of trail
"	437	67.720	Top of Cap, Well 134
"	438	32.252	Top of Cap, Well 140
"	439	64.977	Top of Cap, Well 133

B.W.S. 415

SECONDARY BENCH MARKS - PATCHOGUE SECTION

TABLE 63 (*Continued*)

LOCALITY	B.M.	ELEVATION	DESCRIPTION (25)
Sayville	440	65.298	Bolt in root of Pine Tree, intersection of Wheeler Road and trail running South.
"	441	63.787	Bolt in root of Pine Tree 50' S. of Int. Wheeler Road and Wilhelm Ave.
"	442	55.579	Top of Cap Well 130
"	443	38.851	Top of Cap. Well 129
"	444	51.671	Bolt in root of Pine Tree, N. side Church St. 2000 Ft. E. of Well 129
"	445	35.924	Top of Cap, Well 124 N. 30,829 E. 242,141
"	446	47.271	Top of Cap, Well 171 N. 32,713 E. 243,134
"	447	35.153	Top of Cap, Well 126
"	448	46.055	Top of Cap. Well 125
"	449	56.312	Bolt in root of large Pine S. side Church St. 100' W. of Well 127

B.W.S. 416

SECONDARY BENCH MARKS - PATCHOGUE SECTION

LOCALITY	B.M.	ELEVATION	DESCRIPTION (26)
Sayville	450	56.621	Top of Cap, Well 127
"	451	49.313	Top of Cap. Well 128
"	452	34.145	Top of Cap. Well 170 N. 31,743 E. 244,942
Blue Point	453	43.036	Top of Cap Well 145 N. 31,007 E. 256,622
"	454	46.916	Top of Cap. Well 167
"	455	45.375	Bolt in root of large Oak at intersection of roads, opposite white house.
N. Patchogue	456	61.917	Bolt in root of large twin Oak 500' S. of Well 154 N.E. side of trail.
"	457	45.510	Bolt in root of small Oak 50' N.E. of intersection of trails.
Holtsville	458	78.047	Top of Cap Well 158
"	459	82.626	Top of Cap, Well 152

B.W.S. 417

SECONDARY BENCH MARKS - PATCHOGUE SECTION

TABLE 63 (*Continued*)

LOCALITY	B.M.	ELEVATION	DESCRIPTION (27)
Hollsville	460	82.960	R.R. Spike in Pine Tree 50' N. of Well 152
S. Holbrook	461	74.477	Top of pipe, Well 1196
"	462	72.761	R.R. Spike in Pine Tree, 50' W. of int. of trails & S. side of Wheeler Road
"	463	60.172	Top of Cap, Well 131
Sayville	464	39.561	Bolt in root of Oak Tree at int. of roads, W. side of trails running N.
"	465	39.796	N.W. Cor. boundary monument N.W. Cor. int. of trails
"	466	35.463	Top of Cap, Well 172 N. 29,682 E. 236,808
Holtsville	467	99.528	Bolt in root of Oak Tree, W side trail 200' S. of R.R.
"	468	55.036	R.R. spike in Pine Tree at int. of trails
"	469	43.433	Top of Cap, Well 151

B.W.S. 427

SECONDARY BENCH MARKS - PATCHOGUE SECTION

LOCALITY	B.M.	ELEVATION	DESCRIPTION (28)
W. Blue Point	470	51.098	Top of Cap, Well 141
"	471	61.139	Top of Cap, Well 142
Sayville	472	44.700	Nail in Pine about 30 Ft. W. of Bourne Az. Stake (From B.M. No. 385)
W. Blue Point	473	48.968	R.R. spike in Pine Tree, N. side trail, 300' W. of int. of trails
Plainfield	474	105.478	S.E. Cor. boundary monument 500' E. of R.R. crossing to Plainfield △, Top of bank, N. side R.R.
W. Patchogue	475	54.130	Top of Cap, Well 1169
E. YAPHANK	476	80.412	R.R. Spike in tel. pole No. 1923, 30' N. of track, 150' E. of ■351-H.
"	477		Nail in root of small Pine 110' N.E. ● 15' N. of blazed Pine
Bellport	478	54.060	R.R. spike in tel. pole #6536, S. side R.R. 125' W. of white house
Patchogue	479	12.670	N.W. rivet in N.W. bent Foundation Lace Mill Tower

B.W.S. 428

SECONDARY BENCH MARKS - PATCHOGUE SECTION

TABLE 63 (*Concluded*)

LOCALITY	B.M.	ELEVATION	DESCRIPTION (29)
Patchogue	480	10.800	R.R. Spike in Tel. pole E. end West Lake, N. side of South Country Road.
"	481	15.500	R.R. spike in Wild Cherry Tree on Chapel Ave. 300 ft. N of Swezey Ave.
E. Patchogue	482	14.270	Bolt in root of Forked Wild Cherry 2 m. E. of Patchogue 12½ ft. S.W. Tel. pole 2351 on S. Country Road
"	483	18.090	R.R. spike in Tel. Pole 2380 near Dunton Ave. on. S Country Road
Bellport	484	41.864	Top of Cap, Well 187 N. 39,668.2 E. 283,130.8
Hagerman	485	47.041	Top of Cap, Well 186 N. 39,368.5 E. 281,276.5
"	486	41.220	Top of Cap, Well 185 N. 39,143.2 E. 279,366.4
Bellport	487	51.635	Top of Cap. Well 188 N. 39,729.2 E. 286,283.8
"	488	52.492	Top of Cap Well 343
"	489	54.523	Top of Cap, Well 189 N. 40,854.1 E. 287,745.3

B.W.S. 429

SECONDARY BENCH MARKS - PATCHOGUE SECTION

LOCALITY	B.M.	ELEVATION	DESCRIPTION (30)
Brook Haven	490	52.269	Top of Cap. Well 190 N. 41,406.5 E. 288,982.2
"	491	19.547	Bolt in root of 5" Oak 30 ft. W. of Trail and S. side of Trail running West
"	492	20.041	Top of Cap, Well 191 N. 44,766.5 E. 290,210.9
"	493	35.755	Top of Cap. Well 245 on Yaphank Road
S. Yaphank	494	35.023	Top of Cap. Well 344 on Yaphank Road
Brook Haven	495	37.397	Bolt in Pine Tree at B3r2H
Patchogue	496	3.354	Bolt in notch, top of Pile, Mulford St. Dock
W. Sayville	497	3.778	N.E. Cor. N. Wall brick Bridge
W. Medford	498	85.403	R.R. spike in Tel. pole S. of track at int. Canaan Road
	499		

B.W.S. 430

SECONDARY BENCH MARKS - PATCHOGUE SECTION

TABLE 64

SECONDARY BENCH MARKS—EASTPORT SECTION

LOCALITY	B.M.	ELEVATION	B.W.S. DATUM. DESCRIPTION ①
EASTPORT	E.B.401	23.103	Knob on S. end of stone, 15 ft. E. of Eastport Post Office
EASTPORT	E.B.402	26.932	Spike in 6" pine ¼ mile S.W. of North Country road Crossing R.R. 50' S. of wooded road to R.R.
EASTPORT	E.B.403	47.646	Spike in 8" Pine Tree, On E. side of Road to East Moriches, ½ Mile S. of E.B.402.
EASTPORT	E.B.404	48.074	Spike in 8" Pine Tree On E. side of Road to East Moriches ¾ Mile S. of E.B.403
EASTPORT	E.B.405	46.960	Spike in 10" oak tree on N Country road 500' E. of R.R. crossing 50' N.W. of Church. N. of E. Moriches.
EASTPORT	E.B.406	42.346	Spike in telegraph pole on E. Side of 1st road W. of East Moriches R.R. Sta.
EASTPORT	E.B.407	57.847	Spike in 15" Pine Tree, on W. side of Road to Manor ¾ Mile N. of East Moriches R.R. Sta.
EASTPORT	E.B.408	80.367	Spike in R.R. crossing sign at R.R. crossing, 2 Mile N. of Eastport R.R. Sta, on Manor R.R.
EASTPORT	E.B.409	75.196	Spike in R.R. crossing sign, 1¼ Mile W. of E.B.408 On Manor R.R.
EASTPORT	E.B.410	76.372	Spike in Pine Tree at same R.R. crossing as E.B.409 90' E. along road & 24' S. of road

B.W.S. 500

SECONDARY BENCH MARKS—EASTPORT SECTION

LOCALITY	B.M.	ELEVATION	DESCRIPTION ②
CEN. MORICHES	E.B.411	22.289	Nail in Pine Tree, 75' W. of junction of S. Country Road & Yaphank Road. 33' S. of Road. 1 Mile W. of Cen. Moriches
CEN. MORICHES	E.B.412	35.817	Nail in Oak tree at junction of 1st. Road to East with Yaphank Road after leaving S. Country Road.
CEN. MORICHES	E.B.413	92.402	Spike in Pine Tree ½ Mile from Manor R.R. on S.E. side of road to Center Moriches.
CEN. MORICHES	E.B.414	86.889	Spike in stump of small Oak Tree, 7' W. of center of road leading to main road to Centre Moriches
CEN. MORICHES	E.B.415	90.948	Spike in stump of Pine Tree, 125' S. of Five Points and 15' E. of center of road.
CEN. MORICHES	E.B.416	90.493	Spike in Pine Stump 75' S.W. of Five Points, & 10' S. of center of main road to Center Moriches.
CEN. MORICHES	E.B.417	79.267	Spike in small Oak Tree ¼ M. S.W. of Five Points & 8' S. of centre of main road to Centre Moriches.
CEN. MORICHES	E.B.418	66.346	Spike in Pine Stump 300' S. of Blue House, on W. side of road to Center Moriches. 14' W. of center of road
EASTPORT	E.B.419	30.500	Spike in 18" Oak tree 25' south of ℄ South Country Road 50' East of Warhoo Road
EASTPORT	E.B.420	49.771	Spike in Oak Tree, 125' S.W. of house on N. side of North Country Road, ½ Mile N. of E.B.419.

B.W.S. 496

TABLE 64 (*Continued*)

LOCALITY	B.M.	ELEVATION	DESCRIPTION ③
MORICHES	E.B.421	46.778	Spike in base of pine tree at intersection of 2nd road N. of S. Country road with road to Yaphank.
MORICHES	E.B.422	37.868	Nail in stump S. of Pine Tree, at intersection of 3rd road N. of S. Country road with road to Yaphank
CEN. MORICHES	E.B.423	27.312	Spike in Oak Tree, 1/4 Mile W. of E.B.411, on S. side of main road of Center Moriches, 20' S. of C.L. of road 1 1/2 M.W. of C. Moriches.
MORICHES	E.B.424	61.843	Nail in stump of Oak Tree on Yaphank Road 1/4 Mile N.W. of E.B.422, 25' S. of center of road.
EASTPORT	E.B.425	50.046	Nail in Oak Tree 3/4 Mile N. of E.B.420, 25' E. of center of road to Bald Hill.
MORICHES	E.B.426	13.265	Spike in 2 1/2 Oak Tree on S. side of 1st. pond W. of Center Moriches, 30' N. of center of road
MASTIC	E.B.427	38.393	Spike in Pine Tree 1/4 Mile N.E. of Mastic R.R. Sta. at Junction of Main Road & road to Mastic R.R. Sta.
MORICHES	E.B.428	30.127	Spike in stump of Oak Tree 1/4 Mile N. of E.B.426 on road to Yaphank Road. 125' E. Sec. △ Sta. #4. 15' E. of center of road.
MORICHES	E.B.429	22.116	Spike in large Pine Tree, on road between Twin lakes at Moriches. 1 Mile N. of S. Country Road 125' N.E. of well #294
EASTPORT	E.B.430	37.654	Spike in Pine Stump, on E. side of road to Bald Hill. 1/2 Mile N. of N. Country Road 600' N. of Well #401.

SECONDARY BENCH MARKS - EASTPORT SECTION

B.W.S. 463

LOCALITY	B.M.	ELEVATION	DESCRIPTION ④
EASTPORT	E.B.431	42.464	Spike in Oak Stump 1/4 Mile E. of 420 at junction of N. Country Road & Bald Hill Road #2. on S. side of N. Country Rd.
EASTPORT	E.B.432	22.043	Spike in Pine Tree 1/4 Mile N. of N. Country Road on Bald Hill Road #2. On E. side of road 400' N. of Well #405.
EASTPORT	E.B.433	34.319	Spike in Pine Tree 1 1/4 Mile N. of N. Country Road on Bald Hill Road #2, 300' N. of Well #404 20' W. of center of road.
EASTPORT	E.B.434	72.917	Spike in Pine Tree 2 Mile N. of N. Country Road on Bald Hill Road #2. 10' W. of center of road.
E. MORICHES	E.B.435	62.514	Spike in Pine Tree 1 Mile N. of B.B.37 at E. Moriches R.R. Sta. 25' W. of center of road to Manor.
E. MORICHES	E.B.436	69.406	Spike in Pine Tree 1/2 Mile N. of E.B.435. 8' E. of center of road to Manor.
CEN. MORICHES	E.B.437	44.424	Spike in small Oak Tree on 1st. road W. of Cen. Moriches R.R. Sta. 1/4 Mile N. of Cen. Moriches R.R. Sta. 20' W. of center of road.
SPEONK	E.B.438	31.926	Pt. on W. side of Brick Well of J. Homan, 500' N. of junction of Speonk & Remsenburg Roads
SPEONK	E.B.439	32.864	Spike in large Oak Tree, 600' E. of junction of Speonk & Westhampton Roads. 20' S. of center of W. Hampton Rd.
MORICHES	E.B.440	66.096	1 1/8 M. N. on 1st. road N. of S. Country Rd. on road to Yaphank. Spike in Pine.

SECONDARY BENCH MARKS - EASTPORT SECTION

B.W.S. 464

TABLE 64 (*Continued*)

SECONDARY BENCH MARKS–EASTPORT SECTION

LOCALITY	B.M.	ELEVATION	DESCRIPTION (5)
SPEONK	E.B.441	34.279	Spike in 10" Oak Tree 15' S. of center of W. Hampton Road. 1/2 Mile E of Speonk P.O.
MASTIC	E.B.442	45.718	Spike in 12" Oak Tree. 1/8 Mile W. of Mastic R.R. Sta. 50' N. of R.R. track.
MASTIC	E.B.443	51.744	Spike in 15" Oak Tree on South Country Road 1 Mile W. of road to Mastic R.R. Sta. 100' W. of Frame Shanty
MASTIC	E.B.444	VOID	Spike in stump of 7" Pine Tree 1/2 Mile N. of S. Country Road on line of proposed highway 1500' E. of road to Mastic Sta.
EASTPORT	E.B.445	13.195	Spike in 12" Oak 40' S. of center of Speonk-W. Hampton Road 3/8 Mile E. of Speonk River. 70' S. of Well #409
EASTPORT	E.B.446	26.981	Spike in 7 in. Pine Tree, at Junction of Bald Hill & Brush Neck Roads 1/4 Mile N. of R.R. 40' S. of Well #410.
EASTPORT	E.B.447	58.306	Spike in 7 in. Pine Tree on Brush Neck Road 1 1/8 Mile N. of R.R. 20' S. of Well #412
MASTIC	E.B.448	51.349	Pt. on well curb 20' S.W. of S.W. corner of shanty 50' N.E. of E.B.443 & 50' N. of center of S. Country Road.
MASTIC	E.B.449	60.424	Spike in stump of 6" Pine Tree on 1st. road on S. Country Road W. of R.R. Ave. 1/2 Mile N. of S. Country Road.
MASTIC	E.B.450	28.721	Spike in stump of 7" Pine Tree 1/2 Mile N.W. of Railroad Ave. 40' W. of Well #299.

B.W.S. 418

SECONDARY BENCH MARKS–EASTPORT SECTION

LOCALITY	B.M.	ELEVATION	DESCRIPTION (6)
MASTIC	E.B.451	35.632	Spike in stump of 8" Pine Tree 3/4 Mile N.W. of Railroad Ave. 75' S.W. of Well #298.
MASTIC	E.B.452	69.014	Spike in stump of 6" Pine Tree on road 1 Mile W. on S. Country Road from R.R. Ave. 1 Mile N. of S. Country Road.
MASTIC	E.B.453	65.276	Spike in 5 Twin Oak Tree on 2nd. road W. of R.R. Ave on S. Country Rd. 1 Mile N. of S. Country Road.
SPEONK	E.B.454	51.910	Spike in Triplet Pine Tree on Bald Hill Road #2. (E. branch #2) 1/2 M.N.W. of E.B.446. 3/4 M. N. of R.R.
MASTIC	E.B.455	51.416	Spike in Oak Tree on S. Country Road, 2 1/4 Mile W. of R.R. Ave 25' S. of center of road
MASTIC	E.B.456	60.889	Spike in 6" Pine Tree on 2nd road W. of R.R. Ave. on S. Country Rd. 40' E. of C.L. of road. 1/2 Mile N. of S. Country Road
BROOKHAVEN	E.B.457.	29.209	Spike in Pine Stump 1 Mile N. of U.S.G.S. #19. 1/2 Mile N. of S. Country Road 7' E. of center of road 48' S. of Well #241.
BROOKHAVEN	E.B.458	38.637	Spike in 12" Pine Tree on road to Yaphank 1 Mile N. of S. Country Rd. 36' S. of Well #238 10' W. of center of road.
BROOKHAVEN	E.B.459	36.073	Spike in 12" Pine on road from Brookhaven R.R. Sta. to Yaphank 1/2 Mile N. of S. Country Road
BROOKHAVEN	E.B.460	18.025	Spike in 12" Oak Tree on S. Country Road. 1 1/4 Mile E. of Brookhaven R.R. Sta. 20' S. of center road.

B.W.S. 419

TABLE 64 (*Continued*)

SECONDARY BENCH MARKS - EASTPORT SECTION

LOCALITY	B.M.	ELEVATION	DESCRIPTION (7)
EASTPORT	EB461	70.323	Spike in Pine Tree 20' N. of center of Riverhead Road. 300' E. of Manor Road.
EASTPORT	EB462	65.847	Spike in 8" Pine Stump on Calverton Road. 15' E. of center of road 1 Mile N. of Riverhead Road. Well 1304
SPEONK	EB463	60.033	Spike in Pine Stump on Brush Neck Road 1 M. N. of N. Country Road.
SPEONK	EB464	74.148	Spike in Pine Stump on road to Riverhead. 90' S. of Well 413. 14' W. of center of road.
SPEONK	EB465	79.850	Spike in Pine Stump on road to Bald Hill 2 M. N. of N.C. Rd. 25' S. of Well 403. 10' W. of C.L. of road.
MORICHES	EB466	60.105	Spike in oak stump at Jc. of Main rd. running N. from Twin Lakes and road to Yaphank
SPEONK	EB467	35.464	Spike in 18" oak 60' W. of well #408 10' N. of ℄ of rd. on road running N.W. from Speonk River, halfway between N.C. road and S.C. road.
EASTPORT	EB468	43.760	Spike in 6" pine 10' N. of well #402 1½ M. N. of Jc. of N. Country rd. and Bald Hill rd. Jc. being ½ W. of Wheating.
PAYNEVILLE	EB469	46.865	Spike in 1" oak 10' W. of ℄ of rd. 22' W. of well #248 ¼ M. N. of S. Country rd. on 2ed rd. E. of Carman's River.
S. HAVEN	EB470	26.971	Spike in base of 3" oak 15' S.W. of Well #274 ½ M. N. of South Country rd. and 1 M. W. of Carman's River.

SECONDARY BENCH MARKS - EASTPORT SECTION

LOCALITY	B.M.	ELEVATION	DESCRIPTION (8)
C. MORICHES	EB471	68.386	Spike in 12" oak 1½ M. N. of S.C. rd. on rd. ½ M. E. of R.R. Ave. and ½ M. E. of E.B. 414
BELLPORT	EB472	54.020	Spike in pine tree cut 2' above the ground. 600' N. of R.R. track. ¼ M. E. of R.R. sta. at Bellport at Jc. of road.
BELLPORT	EB473	65.765	Spike in pine tree 6" above ground. ½ M. N. of E.B. 472 15' N.W. of a well 15' from ℄ of road
S. HAVEN	EB474	12.627	Spike in 9" apple tree at S.W. corner Jc. of S. Country rd. and Smith's Point rd
S. HAVEN	EB475	81.957	Spike in oak stump 2' N.E. of Sec. Δ sta. W. Haven. being 300' E. of rd. 1¼ M. N. of Jc. with S. Country rd. which is 1 M. W. from Mastic Sta.
S. HAVEN	EB476	76.249	Spike in pine tree. Point held in root N.E. side of tree which is Sec. Δ sta. E. Haven. which is 700' S. of W. Haven.
PAYNEVILLE	EB477	57.588	Spike in pine tree. Point held in sec. Δ sta. Payne. Go 1 M. E. from Mastic Sta. on. S.C. rd and ¼ M. N. on rd. leading N. Δ sta. is 150' E. of rd.
Eastport	EB478	62.802	Stone at NE cor. of corn crib on property of Charles Skinker
	EB479		Void
S. HAVEN	EB480	34.805	Spike in base of twin oak 235' S. of well #255 5' E. of ℄ of rd. 1½ M. N. of S. Country rd. or 1st rd. E. of Carman's Riv.

TABLE 64 (*Continued*)

LOCALITY	B.M.	ELEVATION	DESCRIPTION ⑨
Mastic	EB481	34.479	Spike in pine tree $\frac{1}{4}$ M. S. of Jc. of Yaphank rd. and rd. running N. from Twin Lakes. 18' N.E. of ℄ of rd. and 38' N. of well 275.
Moriches	EB482	61.629	Spike in base of 4" oak $\frac{1}{2}$ M.W. of Jc. of Yaphank rd. and road running N.W. from Twin Lakes.
Moriches	EB483	73.103	Spike in 8" pine tree $\frac{1}{3}$ M.W. of well 276. $\frac{1}{2}$ M.W of EB 482 8' South of ℄ of Yaphank road.
Mastic	EB484	97.098	Spike in twin oak tree at Jc. of Yaphank rd. and second rd. running N. from Carmen's River E. from S. Country rd.
C. Moriches.	EB485	48.970	Spike in oak stump $\frac{1}{4}$ M.W. of Jc. of Manor rd. and Chichester Ave. 7' E. of well 284. 15' S. of ℄ of road.
C. Moriches	EB486	47.849	Spike in small oak $\frac{1}{2}$ M.N. of well 282. $1\frac{1}{4}$ M.N. of S. Country rd. on rd. leading from C. Moriches school house.
Cen. Moriches	EB487	55.084	Spike in 6" pine on R.R. Ave $\frac{1}{2}$ M.N. of R.R. and 40' E. of ℄ of road.
Moriches	EB488	31.875	Spike in oak tree also △ sta. W. Wheating 300' S. of Baxter's house and 50' W. of ℄ of rd. on rd. leading from Twin Lakes $\frac{1}{4}$ M.N. of S. Country rd.
Moriches	EB489	38.284	Spike in pine tree carrying signal E. Wheating 700' N.E. from E.B. 488
C. Moriches	EB490	65.839	Spike in 12" oak 10' N. of well 273. 7' E. of rd. $\frac{3}{4}$ M.N. of Jc. of Yaphank rd. and rd. running N.E. from Moriches Church.

SEC'DARY BENCH MARKS - EASTPORT SECTION

B.W.S. 475

LOCATION	B.M.	ELEV.	DESCRIPTION ⑩
WESTHAMPTON	501	71.648	Nail in root 4" pine 10' W. of wood road & about 1.5 mile N. of railroad. Location on map: road running from Riverhead to Beaver Lake.
WESTHAMPTON	502	89.576	Nail in root 4" pine, S.E. angle of cross road, N. to Riverhead E. to Westhampton Road. B.M. is 6' from intersection. Same road as B.M. #501
WESTHAMPTON	503	44.998	Bolt in root 8" pine at S.E. angle of intersection of R.R. and secondary road about $\frac{1}{2}$ mile E. of Westhampton Station. Secondary road is third crossing E. of Westhampton Station.
WEST HAMPTON	504	43.515	Bolt top stump 2" pine, 17' E. of ℄ road & 71' N. of N. rail of R.R. Stump is 1' above ground. Road is fifth crossing E. of Westhampton.
WESTHAMPTON	505	47.586	Bolt root 3" pine, 12' W. of ℄ of road & 1 mile N. of track. Tree is stripped of branches and 6.5' high. Road is fifth E. of Westhampton.
WESTHAMPTON	506	39.655	Bolt in root 3" dwarf pine 25' W. ℄ road & 25' N. of intersection of roads, near tel. pole #69 about $1\frac{1}{2}$ miles N. of R.R.

SECONDARY BENCH MARKS - EASTPORT SECTION

B.W.S. 576

TABLE 64 (*Continued*)

LOCATION	B.M.	ELEV.	DESCRIPTION (11)
WESTHAMPTON	507	30.045	Bolt root 4" pine, 35.5' of well #422 and 37' N. of tel. pole #53 and 15' W. of ℄ of road to Quogue.
QUOGUE	508	43.837	Bolt root 3" pine stump at intersection of roads, 3000' N. R.R. Road S. crossing R.R. 1 mile W. Quogue Sta. B.M. is 5' E. of N.&S. road & 6' W. of E. & W. road and 4' from tree marked B.M. 508
WESTHAMPTON	509	51.735	Bolt in root 6" pine 12' E. of ℄ of third road E. of Westhampton Station and 2160' N. of R.R.
WESTHAMPTON	510	61.326	Bolt in root lone 6" pine, 35' W. ℄ road, about 1000' N. of intersection of roads to N.E. B.M. is on second road E. of Westhampton Station, one ½ mile N. of R.R.
QUOGUE	511	21.333	Nail root 8" oak on S. side track & about 25' W. road at crossing W. of Quogue Station.
WESTHAMPTON	512	25.378	Bolt root 12" pine standing alone, in gully on third road E. of Westhampton Sta. B.M. is about 900' N. of track & 10' W. of wood road, and 10' W. of Test Well #421.
WESTHAMPTON	513	51.179	Bolt in root 4" pine, 23' W. of ℄ of road, about 1 mile N. of track, about 3000' N. intersection of roads. B.M. is on third road E. of Westhampton.

SECONDARY BENCH MARKS - EASTPORT SECTION

LOCATION	B.M.	ELEV.	DESCRIPTION (12)
WESTHAMPTON	514	76.324	Bolt in root 3" pine in N.E. angle of roads 35' E. of N. & S. roads & 20' N. of E. and W. roads, and about 1½ miles N. of R.R.
WESTHAMPTON	515	77.565	Bolt in old stump at intersection of pipe line and old road running S., about 1 mile from Old Quogue Road. B.M. is located on top of hill, & in S.W. angle of roads. Has no marker and is 2 miles N. of tracks.
QUOGUE	516	63.017	Bolt in root 5" oak at intersection of roads - S.E. angle - near tel. pole #115 on Old Quogue Road about ⅝ mile S. of New Quogue Road
WESTHAMPTON	517	31.590	Bolt in root 12" pine in N.W. angle of cross roads, ⅜ mile S. R.R. Rds. run E. & W. to Quogue and N. & S. direct to Westhampton Sta.
RIVERHEAD	518	15.364	Bolt in root 24" twin oak, 39' W. ℄ of road & 15' N. Swezy Pond & about 5' S. of intersection of secondary road to West.
RIVERHEAD	519	19.159	Bolt in root 8" twin oak 45' N. Great Pond, at fork of road. Road runs S. from Riverhead forking at Great Pond.
RIVERHEAD	520	17.706	Nail in side 5" pine, S.W. corner Swezy Pond, about 40' S. of point where fill road begins. Pond is divided by a fill road running N. & S. On W. side 1' above ground.

SECONDARY BENCH MARKS - EASTPORT SECTION

TABLE 64 (*Continued*)

SECONDARY BENCH MARKS - EASTPORT SECTION

LOCATION	B.M.	ELEV.	DESCRIPTION (13)
RIVERHEAD	521	17.188	Nail in side 3" pine 245' E. inter. roads & about 25' N. of road, & 45' S. edge pond inter. secondary roads running N. E. & S.W. 1½ miles S.E. R'hd. in angle bet. Flanders & Quogue Road.
RIVERHEAD	522	22.157	Nail in side large cluster willows at inter. of main & secondary roads. Near hotel sign 3 miles W. R'hd. & 1500' S. R.R.
RIVERHEAD	523	21.385	Nail in side 5" pine at foot steep slope from road to pond. At right angles to road at point marked by blazed tree. About 1 mile S. of Power House on road with cycle path.
RIVERHEAD	524	19.359	Large nail bent like staple in side 3" oak at edge water, 5' S. road & about 50' W. of point where sand & swamp roads meet. About 2½ miles from Riverhead.
RIVERHEAD	525	23.609	Bolt in root 6" oak N. side main road & E. side pond about 2 miles N.W. R'hd. At point where secondary joins main road at pond.
RIVERHEAD	526	19.009	Nail in root large cluster oak at foot slope from road to pond. About 50' from road & at S. end of pond, about ½ mile N. of RR. on first road W. of Raynor Ave.
RIVERHEAD	527	17.635	Head of bolt in 8"X10" beam foot runway N.W. corner icehouse about ½ mile N. of R.R. & 500' E. of Roanoake Ave.

B.W.S. 494

SECONDARY BENCH MARKS - EASTPORT SECTION

LOCATION	B.M.	ELEV.	DESCRIPTION (14)
RIVERHEAD	528	28.987	Nail in root 13" twin oak foot slope, about 15' from S. edge of pond at point opposite site small pond on S. side road at turn 1000' from intersection of road 1 mile N. of R.R.
RIVERHEAD	529	59.419	Bolt in root 14" oak on N. side Middle Country Road at inter. of secondary road S.W. to Wading River Road 4 miles W. of Riverhead.
RIVERHEAD	530	30.536	Bolt in root 5" oak, center one of three in S.E. angle M.C. Road & road running N. & S. from Riverhead to Centerville, 35' from Riverhead road & 20' from Middle Country Road.
RIVERHEAD	531	29.741	Bolt in root twin oak at gate of property at corner of Roanoake Ave. & M.C. Road. B.M. is 35' E. ℄ road & about 600' S. M.C. Road on S. side of gate.
RIVERHEAD	532	35.095	Bolt in root 12" locust on site of old farmhouse, now burned down. B.M. is on M.C. Rd, 1¼ m. E. of Roanoake Ave. & 5' inside of fence at gate to barn.
RIVERHEAD	533	20.151	Bolt in root 8" oak in angle of M.C. Rd. & R'hd. road & road known as Doctors Path. 2½ miles W. of Aquebogue.
CENTERVILLE	534	103.073	Bolt on knob at of 24" tulip tree at inter of No. Country Road & Roanoake Ave. On E. side Roanoake Ave. 15' from ℄ of road & 55' N. of North Country Road.

B.W.S. 501

TABLE 64 (*Continued*)

LOCATION	B.M.	ELEV.	DESCRIPTION (15)
CENTERVILLE	535	76.260	Bolt in cherry tree in S.W. angle of cross roads 1 mile S. of N.C. Road on Roanoake Ave., On property of W.H. Dayton.
RIVERHEAD	536	21.352	Bolt in E. side of Tel. pole, 2' from ground on S. side of pond abut 1000' N. of intersection of N.C. Road & Roanoake Ave. Tel. pole is on edge of water 100' W. of ℄ of Roanoake Ave.
AQUEBOGUE	537	38.635	Head of nail in 10" tree in Front of property of Daniel Wells on Middle Country Road - Aquebogue.
AQUEBOGUE	538	34.630	Bolt in root 14" tree opposite white church and also blacksmith's shop. On fourth tree from corner of cemetery.
AQUEBOGUE	539	31.653	Bolt in cluster of oaks at intersection of roads 1 mile N. of M.C. Rd. Aquebogue. On second road running N. from M.C. Road E. of church & in angle of private road & small white house.
NORTHVILLE	540	61.560	Knob on S.E. corner of horse-block in front of church on N.C. Road opposite inter. of road to South. On bottom of block.
NORTHVILLE	541	59.921	Bolt in root of 14" maple on N.C. Rd. 75' E. of gate at residence of H.R. Luce, about half way between roads South.
NORTHVILLE	542	62.036	Bolt in root large oak on property of John Reeves at inter of N.C. Road & road to south. B.M. is 75' S. of intersection.
AQUEBOGUE	543	80.662	Bolt in root 12" maple S. side of N.C. Road 375' W. of road to S. to M.C. Road 1 m. W. of Aquebogue, on property of E.A. Fanning.

SECONDARY BENCH MARKS - EASTPORT SECTION

B.W.S. 502

LOCATION	B.M.	ELEV.	DESCRIPTION (16)
CENTERVILLE	544	86.670	Bolt in root of large oak in S.W. angle of N.C. Rd. & road S. to Riverhead. 1¼ m. E. of Roanoake Ave. opposite residence of W. Aldrich.
CENTERVILLE	545	103.548	Bolt in root of large oak in N.W. angle of N.C. Road & road N. to Friars Head. About 1 mile W. of Roanoake Ave.
BAITING HOLLOW	546	97.185	Bolt in root 14" lone oak in triangle formed by N.C. Road & road S.E. to Riverhead. B.M. is 1 mile E. of Baiting Hollow.
BAITING HOLLOW	547	77.038	Nail in root of 12" locust tree on N. side of Baiting Hollow Pond about 60 ft. S. of North Country Road.
BAITING HOLLOW	548	112.248	Knob on top of mile stone at corner of N.C. Rd. & road S.E. to Riverhead. Stone is opposite P.O. & on E. side of stone over figure 2.
BAITING HOLLOW	549	86.751	Bolt in root of 10" lone oak at intersection of roads 1 mile S. of Baiting Hollow. In S.W. angle of roads.
RIVERHEAD	550	62.284	Bolt in root of 10" oak in S.W. angle of cross roads, N. & S. from Riverhead to Baiting Hollow & E. & W. from Roanoake Ave. to B.H. Road 1½ miles S. E. of Baiting Hollow.
RIVERHEAD	551	39.883	Bolt in root of dead oak on N. side pond, 300' S. of road & at right angles to point marked by blazed pine. Secondary road S. about ½ m. E. of W. River Rd. & M.C. Rd. Pond is about 500' from main road.
RIVERHEAD	552	61.502	Bolt root 10" twin oak on N. side secondary road S. from W.R. Road ab. point ½ m. E. of inter. of W. River & M.C. Rds. B.M. is 1 m. S. of main road.

SECONDARY BENCH MARKS - EASTPORT SECTION

B.W.S. 491

TABLE 64 (*Continued*)

SECONDARY BENCH MARKS - EASTPORT SECTION

LOCATION	B.M.	ELEV.	DESCRIPTION (17)
CALVERTON	553	22.014	Bolt root 8" twin oak on road to Calverton. 300' W. Middle Road & 2000' N. of ice-house. B.M. on S. side Calverton Rd. at swamp, 10' S. of tel. pole 2016
CALVERTON	554	26.415	Bolt in root of large elm at foot of hill 600' S. of Calverton Church. B.M. is 100' E. of intersection of roads.
CALVERTON	555	35.496	Bolt in root of apple tree at corner of small building on property of Geo. Neidergross, on river road, 1m. W. R.R. crossing. 40' S. of well.
CALVERTON	556	30.865	Nail in side of 6" tree, E. side road at swamp about 1m. N. of R.R. & about 2m. W. of Calverton. On blazed tree.
CALVERTON	556A	30.335	Bolt in S.W. corner of bridge on first plank. Bridge is ¾ m. N. of R.R. & 2 m. W. of Calverton.
BAITING HOLLOW	557	114.455	Bolt in root of 18" magnolia tree in front of residence of E. L. De Friest, on N.C. Road about 4 m. E. of Wading River.
BAITING HOLLOW	558	128.587	Bolt in root of large oak on property of J. Geider on N.C. Rd. about ½ m. W. of Baiting Hollow.
BAITING HOLLOW	559	114.377	Bolt in root of large tree in angle of roads formed by N.C. Road & road to N. Wading River. B.M. is 2¼ m E. of Wading River.
WADING RIVER	560	101.014	Bolt in root of 8" oak at intersection of roads about 1⅛ m. E. of Wading River. Roads run S.E. to Riverhead - N.W. to Wading River.
WADING RIVER	561	92.075	Bolt in root of large locust tree at intersection of roads at Wading River Village. B.M. is in S.E. angle of roads.

B.W.S. 492

SECONDARY BENCH MARKS - EASTPORT SECTION

LOCATION	B.M.	ELEV.	DESCRIPTION (18)
WADING RIVER	562	48.351	Bolt in root of 8" cluster oak at E. side of Long Pond, about 75' S. of intersection of roads & 35' E. of Pond.
WADING RIVER	563	42.716	Bolt in root of oak on W. side of Deep Pond about 75' from edge of water - 10' S. of road & about 250' N. of small building
CALVERTON	564	27.511	Bolt in root of 8" pine at intersection of secondary roads & about 1 mile S. of Calverton.
MANOR	565	39.534	Bolt in root of large tree at intersection of roads on way to Manor - 3 miles W. of Calverton.
MANOR	566	71.290	Bolt in root of 6" oak at intersection of secondary roads - 4 m. W. of Calverton & 1 m. E of Forest Lake N. of Manor Station.
MANOR	567	65.603	Bolt in root of 6" cherry in N.W. angle of cross roads about 5 m. W. of Calverton, on property of J. J. Berman.
MANOR	568	50.814	Bolt in root of large twin oak opposite Manor School at intr. of rds.
MANOR	569	41.648	Bolt in root of 10" oak on secondary road running S. 1m. W. of Manor Station. B. M. is ¼ m. S. of track at small pond where teams drive down to water.

B.W.S. 503

TABLE 64 (*Continued*)

LOCATION	B.M.	ELEV.	DESCRIPTION (19)
MANOR	570	46.094	Bolt in root of tree in N. side of Forest Lake about 200' S. of white house. 50' S. of road & 36' E. of road leading to water.
MANOR	571	44.285	Bolt in root of 10" oak at intersection of Main Road & secondary road to S., & 150' S. of junction of roads about 1¼ m. N. of Manor Sta.
MANOR	572	38.580	Bolt in floor at N.W. corner of bridge ¾ m. N. Manor Sta. on Main Road.
MANOR (SOUTH)	573	49.198	Bolt in root of 14" locust at S.W. corner South Manor Church
MANOR	574	46.053	Bolt in trunk of large tree near angle in road & about 150' E. of small house on main road 1¾ m. W. Manor. 2½' above ground
MANOR	575	42.845	Bolt in root of large willow on main road about 2 m. W. Manor. B.M. is at small house opp. pond & at inter. with road S. along farm
MANOR (SOUTH)	576	50.274	Bolt in root of 24" oak in front of house of Geo. E. Davis. B.M. is 1¼ m. W. of church.
MANOR (SOUTH)	577	38.396	Bolt in root of 12" tree on E. side of pond at N.W. angle of R.R. & secondary road about 1¾ m. S. of Manor.
MANOR	578	55.935	Bolt in root of large tree in front of small house 200' S. of intersection of roads & about 2 miles S.E. of Manor.

SECONDARY BENCH MARKS - EASTPORT SECTION

B.W.S. 504

LOCATION	B.M.	ELEV.	DESCRIPTION (20)
MANOR	579	40.283	Bolt in root of tree on E. side of Swan Pond - 2½ m. N.E. of Manor on N. side of road.
MANOR	580	38.189	Bolt in S.W. corner of bridge at intersection of secondary road and Peconic River ⅝ m. W. of Manor & ½ m. N. R.R. on end floor beam.
MANOR	581	39.836	Bolt S.E. corner of bridge at intersection of secondary road & Peconic River 1¼ m. W. Manor & ⅞ m. N. of track.
MANOR	582	40.944	Bent nail in floor of bridge over Peconic River 2½ m. W. of Manor & ½ m. N. of R.R. on secondary road about 100' N. of main road. In N.W. corner of bridge.
MANOR	583	43.274	Nail in side of 5" twin oak on E. side brook & S. side road along 1 m. N. of main road & 2½ m. N.W. of Manor R.R. Station
YAPHANK	584	41.077	Head of bolt in cross beam over sluiceway at N.E. corner of Easterly one of two bridges on site of old mill about 1 m. W. of Yaphank Post Office.
YAPHANK	585	56.576	Bolt in 12" oak at intersection of secondary roads 1 m. E. of Yaphank Mill & 900' E. of residence of Mrs. Clara Weeks. B.M. is 15' N. of well #216.

SECONDARY BENCH MARKS - EASTPORT SECTION

B.W.S. 498

TABLE 64 (*Continued*)

SECONDARY BENCH MARKS – EASTPORT SECTION (21)

LOCATION	B.M.	ELEV.	DESCRIPTION
YAPHANK	586	126.497	Knob on top of large boulder on S. side secondary road opp. residence of W. Vanderbilt. B.M. is $\frac{1}{2}$ m. E. main road & opp. small pond.
YAPHANK	587	55.807	Bolt in small cluster oak at inter. of roads $\frac{3}{4}$ m. N. R.R. & $1\frac{1}{3}$ m W. Yaphank Sta. B.M. is E. of main road & S. of secondary road.
YAPHANK	588	79.478	Bolt in old apple tree on edge of road opp. S. end pond. Road runs S. along chain of ponds $1\frac{1}{8}$ m. W. of Middle Island. B.M. is $\frac{1}{4}$ m. S. of main road.
MIDDLE ISLAND	589	78.745	Bolt in root of 12" maple on edge of pond at intersection of road & driveway to residence of Judge Bartlett. B.M. on same road as #588 & 1 m. S. of Middle Country Road
PLAINFIELD	590	112.384	Bolt in 6" cluster of oak on W. side road at point where approach to bridge intersects main road, $1\frac{7}{8}$ m. E. of Plainfield Sta. & $1\frac{3}{4}$ m W. Yaphank. B.M. is at sharp angle & about 300' N. R.R. track
NO. PLAINFIELD	591	120.554	Head of large nail at base 5" twin oak at junction of road $1\frac{1}{2}$ m N. E. of Plainfield. B.M. is midway between two houses at point where secondary roads to W. join main road.

B.W.S. 499

SECONDARY BENCH MARKS – EASTPORT SECTION (22)

LOCATION	B.M.	ELEV.	DESCRIPTION
YAPHANK	592	91.683	Nail in root of 8" oak at intersection of main road & secondary r'd. to E. about $\frac{1}{3}$ m. W. of Carman's Creek & about $\frac{3}{4}$ m. N.W. of junction of roads W. of Yaphank.
CORAM HILL	593	166.683	Bent nail in root of 15" walnut 30' S. of barn of S.S. Davis & 300' from intersection of roads at Coram Hill.
CORAM HILL	594	154.542	Nail in root of 10" oak on E. side road nea small pond about $\frac{1}{3}$ m. N. of inter. of roads at Coram Hill. B.M. is at lap of gentle slope from pond.
MANOR	594A	47.673	Nail in root of 12" oak about 15' W. of test well #269 about 3 m. W. of Manor & $1\frac{3}{4}$ m. N. of R.R. track.
MANOR	595	61.431	Nail in root of large tree opp. residence of J.A. De Groot. House $\frac{3}{4}$ m. S. of church.
SHOREHAM	595A	134.614	Nail in side of Shoreham Inn sign post 0.1' above ground at intersection of roads $\frac{1}{2}$ m. W. of Shoreham R.R. Station.
MIDDLE ISLAND	596	64.101	Nail in root of large tree 10' S. of gateway to pond & 75' E of pond 2 m. N. of Country Road at M. I. Pond is opp. house on E. side road.

B.W.S. 489

TABLE 64 (*Concluded*)

SECONDARY BENCH MARKS - EASTPORT SECTION

LOCATION	B.M.	ELEV.	DESCRIPTION (23)
MIDDLE ISLAND	597	92.214	Nail in root of large oak opp. M.I. Church & school & also opp. inter. of roads $1\frac{1}{4}$m. W. of M.I. Post Office.
LONG POND	597A	58.421	Nail in root of 10" pine near small pond $\frac{1}{2}$m. S.W. Long Pond & 1m. N. of Country Road. B.M. is on S. side of road.
MIDDLE ISLAND	598	63.246	Nail in root of 10" oak on property of F. Davis-$\frac{7}{8}$m. N. of M.I. Church. B.M. is 100' E. pond & stands alone in triangle formed by roads
MIDDLE ISLAND	599	92.221	Nail in root of large magnolia in angle of fence on property of J. Mart. 2m. N. M.C. Road as B.M. 598 & 75' S. of pond.
MIDDLE ISLAND	600	118.787	Nail in top of bend in crooked tree in N.E. angle of cross roads 3m. N. of Coram on Mt. Sinai Road
RIDGE	601	87.631	Nail in root of 16" oak on N. side Whiskey Road 200' W of house of Chas. Randall-2m. N.W. of Ridge.
RIDGE	602	86.441	Nail in root of 10" walnut at intersection of road opp. residence of J. Randall. B.M. is at S.W. angle of inter. $1\frac{1}{2}$m. N. of Ridge.
CORAM	603	91.272	Nail in root of 5" locust, inside of gate on N. side M.C. Rd. opp. residence of J. Smith - 1m. E. Coram & 40' W. of public pump.

B.W.S. 490

SECONDARY BENCH MARKS - EASTPORT SECTION

LOCATION	B.M.	ELEV.	DESCRIPTION (24)
RIDGE	606	74.139	Nail in root of larg oak near S.W. corner of residence of F.E. Ellis $\frac{1}{2}$m. W. of Ridge.
RIDGE	607	61.579	Nail in root of one of two 10" oaks in triangle formed by roads at E. end of bridge $\frac{1}{2}$m. W. of Ridge. Tree is marked BS 60.
RIDGE	608	60.451	Nail in root of 10" locust, 25' from edge of pond & 125' W. of road - in rear of barn $\frac{1}{2}$m. N. of Ridge & 500' N. inter. of roads.

B.W.S. 496

APPENDIX C

TOPOGRAPHICAL SURVEYS

BY JOHN L. HILDRETH, JR., ASSISTANT ENGINEER

As soon as the triangulation work was well advanced in the spring of 1907, the topographical surveys along the proposed aqueduct locations were started. All the traverses were carefully chained, but the topography was taken entirely by stadia methods.

Organization

The survey parties were made up as follows: Assistant engineer in charge, one instrument man (rodman or axeman), recorder (rodman or axeman), and four to six axemen and laborers to run stadia rods and clear the lines, and chain the distance between stations.

Methods of Work

Parties of this make-up were usually able to cover a strip from 600 to 2000 feet in width, at the rate of about 1½ miles per week. With the exception of one or two small traverses at the outset, all stadia traverses were measured with a chain and the distances corrected for temperature and to United States Standard. Numbers were adopted for the traverses; 1 to 299 for Babylon, 300 to 599 for Patchogue, 600 to 899 for Moriches, and 900 to 1199 for Jamaica division. Stadia stations were given the traverse number and lettered from A to Z. Shots were recorded by noting the time at which they were taken and also the rodman's name; for example, a shot taken at 10:15 on Rodman Powell would be marked " 1015P."

The assistant engineer in charge used the same notation in plotting all important shots on the sketches of the topography that he made in his book, so that the office force could readily work up the details of the maps.

At the outset it was recognized that in the western part of Suffolk county, where the land was comparatively level and covered with a growth of scrub oak and pine from 8 to 10 feet high, with an ordinary tripod a great deal of trimming would be required to properly cover a strip 1000 feet in width, which was considered necessary. In order to overcome this difficulty, a tripod 8½ feet high for the instrument, and a collapsible platform for the instrument man to stand on, were designed. One of these tripods and a platform are shown on

Plate 55. Six sets of these were built and proved very satisfactory. They permitted the instrument man to see over all brush that was not over eight feet high, and the shots could be placed to great advantage at a distance of 600 to even 1500 feet from the instrument, with very little trimming. Rods 16 feet in length were used, and nearly all readings were level readings, which very materially reduced the office work and eliminated many opportunities for error.

The heads of these tripods were made of two layers of white pine ½ inch thick and a top layer of oak of the same thickness, with the grain crossing, and all held together by brass screws. The six cleats forming the bearings for the legs were bolted to the top with ½-inch bolts, the 3 inner ones being one inch longer to hold the hexagonal stiffening piece on the bottom. The heads of all bolts were flat and set flush with the top so as not to interfere with the trivet on which the transit was mounted. In the center of the top was a round hole five inches in diameter, which gave plenty of room for shifting the instrument when setting up over a station. The legs were of oak three inches by four inches at the top and tapering to 1½ inches by two inches at the bottom, grooved for five feet in order to lighten them, and shod with iron shoes having a lip at the top to drive them into the ground.

The platform was triangular, the top being about four feet on a side. The stand consisted of two panels made of two uprights, two inches by four inches, held together at the top and bottom by a 1-inch by 3-inch strip with a diagonal of the same size. These panels were hinged together by two tight butt hinges. The third side consisted of two diagonals one inch by three inches, hinged at the top by tight butt hinges and at the bottom by loose butt hinges. By pulling out the loose hinges these diagonals could be folded in and the two side panels folded together and hooked for transportation. The top was hooked to the stand at all three corners. Twenty-four-ounce plumb-bobs were used and the instrument hight taken with a steel tape.

In the central and eastern portion of Suffolk county these tripods could not be used to much advantage, on account of the rough country and heavy growth of trees above the top of the tripods. Here the ordinary tripod was used and short spur lines were run on both sides of the main traverses, in order to cover the ground without unnecessary trimming.

The method of the field work was as follows: A transit was set up on the ordinary tripod, or, if the high tripod was

used, on a trivet. The angle from the rear station to the forward station was turned from left to right from two to four times, using either sight rods or plumb-bobs for sights, and the value of the angle computed. The instrument was then set on the back azimuth and on the back station, then turned to the forward station and the forward azimuth read as a check on the calculated azimuth. The magnetic bearings of both lines were also read as a check. Stadia distances and difference of elevation to both stations were also observed to check the chaining. When the stations were over 500 feet apart, a field check for elevation was made by setting up the transit half-way between the stations and taking level readings on both. In this manner it was possible to carry the levels very accurately from one bench-mark to the other.

In taking the topography, the stadia rods, two to four in number, were strung out at right angles on one side of the line 150 to 500 feet apart, depending on the character of the ground, and all moved forward as far as desired. They then crossed the line and moved back towards the instruments, maintaining the same interval. In some of the parties, whistles were used to direct the rodmen in the thick scrub oak when they were out of sight of the instrument most of the time. Each rodman had a number by which he could be called. When the instrument man sighted on a rod, he gave the rodman's whistle number, and if he wished him to move to the right he gave one short blast, or to the left two short blasts of the whistle. When the instrument man had finished, he gave the rodman's number again followed by one long blast, when the rodman turned his rod, with his back to the instrument, and moved to the next point as directed by the head of the party. This was found to be a very easy and quiet manner of handling a party in the field.

The traverses were run between triangulation stations, and as soon as the closure was made and the traverse completed, the notes were turned in to the office to be reduced, and checked and plotted.

There were two methods employed in closing these traverses; either the error of closure in azimuth was distributed equally through all the sides of the traverse, and the traverse then closed, or it was closed without any correction in azimuth. After the error was determined, it was distributed in the usual manner through the northings, southings, eastings and westings, and the corrected distances, bearings and co-ordinates of the stations calculated.

The work was plotted on white mounted paper sheets, 26 inches by 40 inches, to a scale of 1 inch equals 200 feet. The working sheet consisted of three squares by two squares, the co-ordinate lines being 2400 feet (or 12 inches) apart each way.

The stadia stations were first plotted by their co-ordinates, with the number of stations, the elevation and the line connecting the stations inked in. The side shots were then plotted and, in most cases, inked in. Then the topography and contours were usually put in in pencil and afterwards inked.

By this method, as soon as the shots were plotted and inked the contours could be drawn in, if necessary, and in no case would the elevations be obscured by any of the following work.

Average error of closure of traverse 1/5900.

SUFFOLK COUNTY SURVEYS

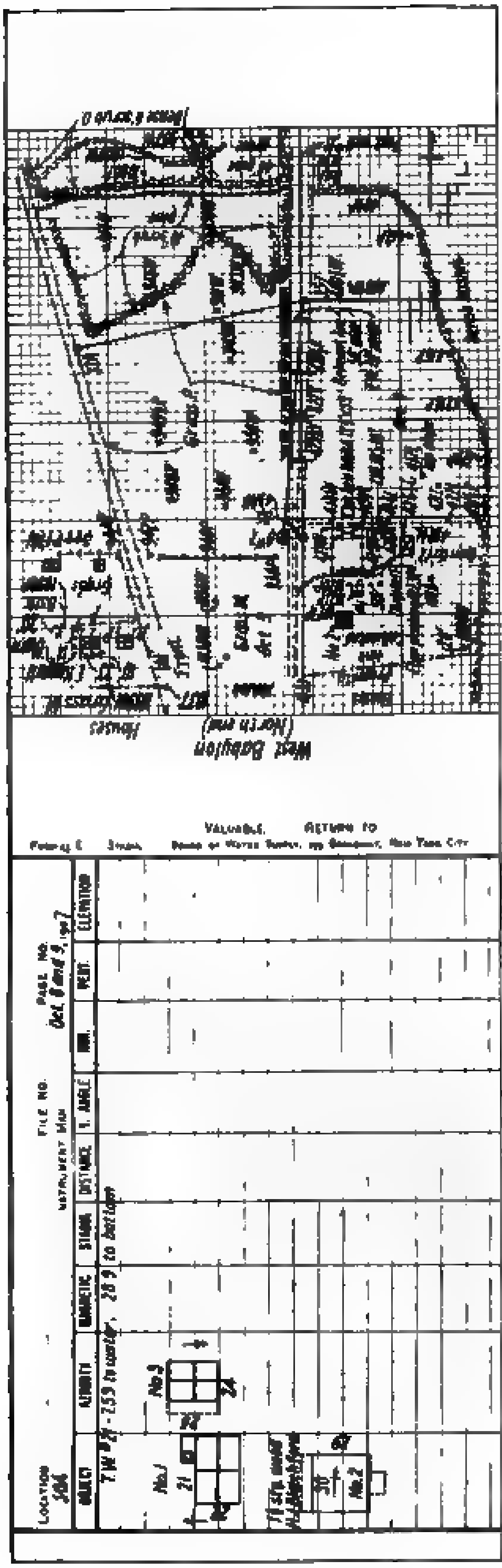
The amount and cost of work in Suffolk county is as follows:

Length of traverses, miles	213.3
Number of stations	2,595
Approximate number of shots	41,838
Area covered	
Square miles	28.76
Acres	18,406
Number of topographical sheets, 26 inches by 40 inches	134
Salaries (survey and calculation), materials, etc. (no executive)	$42,058.85
Six 8½-foot tripods at $20	120.00
Six platforms for 8½-foot tripods at $6	36.00
Total cost	$42,214.85
Cost	
Per mile of traverse	$197.90
Per square mile	1,467.83
Per acre	2.29

On Sheet 174, Acc. 16094, is shown a typical set of field notes and tabulations of errors of closures of the traverses in Suffolk county.

All traverses were tabulated on 8½-inch by 11-inch tracings which, when blue printed, could be cut into 5-inch by 8-inch sheets to insert in field note-books.

SHEET 174



CHIEF OF PARTY'S NOTES

TABLE 65

Tabular Statement of Error in Closure of Stadia Traverses, Suffolk County

Traverse Number	Length of Traverse Feet	Length of Traverse Miles	Azimuth Closure Error Minutes	Azimuth Closure Error Seconds	Error of Closure
1	8,536.4	1.616	02	57.8	$\frac{1}{1738}$
1U	2,484.1	0.470	01	20	$\frac{1}{1533}$
2	3,412.5	0.646	..	..	$\frac{1}{2280}$
4	6,233.2	1.180	00	40	$\frac{1}{1070}$
5	862.7	0.163	02	00	$\frac{1}{750}$
6	4,180.8	0.791	02	00	$\frac{1}{1060}$
7	2,253.1	0.426	00	20	$\frac{1}{1050}$
9	3,204.6	0.608	01	00	$\frac{1}{1730}$
10	7,365.6	1.395	01	40	$\frac{1}{1370}$
10B	2,413.31	0.457	02	54.5	$\frac{1}{687}$
10N	5,488.19	1.039	02	02.5	$\frac{1}{1660}$
11	8,092.28	1.532	00	13.1	$\frac{1}{9954}$
12	5,310.93	1.005	01	00	$\frac{1}{11908}$
13	1,921.08	0.363	00	20	$\frac{1}{10673}$
14	6,850.24	1.297	00	15	$\frac{1}{8782}$
15	6,809.73	1.289	00	03	$\frac{1}{7918}$
16	5,516.52	1.044	00	01.3	$\frac{1}{22986}$
17	5,068.40	0.959	00	07	$\frac{1}{4407}$
18	12,687.61	2.402	01	02.8	$\frac{1}{4301}$
19	8,974.06	1.697	02	26.8	$\frac{1}{3771}$
20	11,268.88	2.134	00	03	$\frac{1}{7270}$
21	14,213.28	2.691	02	54	$\frac{1}{3900}$
21R	1,623.06	0.372	02	40	$\frac{1}{1350}$

TABLE 65 (*Continued*)

Traverse Number	Length of Traverse Feet	Length of Traverse Miles	Azimuth Closure Error Minutes	Azimuth Closure Error Seconds	Error of Closure
22	7,731.51	1.464	01	57	$\frac{1}{5000}$
23	23,019.67	4.359	04	43.6	$\frac{1}{5137}$
24	10,160.28	1.924	00	11	$\frac{1}{8680}$
24, 25, 26, 27	12,734.00	2.411	01	23.8	$\frac{1}{7240}$
26	2,541.14	0.481	00	43	$\frac{1}{5500}$
31	10,777.25	2.041	00	44	$\frac{1}{5092}$
33	3,477.63	0.658	00	28	$\frac{1}{6200}$
35A	7,861.59	1.489	00	14	$\frac{1}{24499}$
35	3,779.49	0.715	00	29	$\frac{1}{6268}$
37	5,857.87	1.109	03	28	$\frac{1}{4650}$
38	7,757.04	1.469	00	02	$\frac{1}{13202}$
41	4,547.00	0.861	00	02	$\frac{1}{7100}$
43	7,855.43	1.487	01	05.3	$\frac{1}{8100}$
44	17,156.81	3.249	01	38	$\frac{1}{2120}$
45	20,209.00	3.825	00	21.5	$\frac{1}{3490}$
46	7,194.50	1.362	00	22	$\frac{1}{3650}$
301	10,161.15	1.920	00	30	$\frac{1}{5670}$
302	6,644.93	1.258	01	05	$\frac{1}{8306}$
303	6,953.08	1.317	02	30	$\frac{1}{4730}$
304	6,520.51	1.234	00	42	$\frac{1}{12075}$
305	8,560.98	1.620	00	02	$\frac{1}{47561}$
306	15,445.84	2.925	01	10	$\frac{1}{51486}$
307	9,546.56	1.807	01	40	$\frac{1}{2993}$
308	7,093.48	1.343	00	10	$\frac{1}{3385}$

TABLE 65 (*Continued*)

Traverse Number	Length of Traverse Feet	Length of Traverse Miles	Azimuth Closure Error Minutes	Azimuth Closure Error Seconds	Error of Closure
309, 310	21,689.68	4.110	00	07	1/3973
311, 312	11,896.43	2.250	01	50	1/3992
313	1,910.49	0.362	00	41	1/3294
314	12,004.75	2.270	02	30	1/3017
315	11,395.72	2.155	01	10	1/3600
316, 357	4,427.99	0.838	00	20	1/1800
317–1	9,218.87	1.745	01	20	1/4300
317–2	2,959.63	0.560	00	20	1/1470
317–3	3,093.77	0.585	00	10	1/4650
319–1	6,853.85	1.298	00	00	1/3720
319–2	1,566.41	0.296	00	03	1/1740
320	4,100.35	0.776	00	14	1/6530
321	3,874.74	0.733	00	03	1/3500
322	6,096.95	1.153	01	10	1/8240
323, 325	4,993.84	0.945	01	20	1/5095
324	4,745.26	0.898	00	20	1/2372
326	6,014.66	1.139	00	03	1/3700
327	6,579.56	1.285	02	03	1/1717
328	2,967.20	0.562	00	40	1/1639
329	3,031.87	0.574	00	50	1/1255
330	3,595.50	0.681	00	33	1/1350
331	8,936.47	1.690	00	08	1/2448
333	3,255.84	0.617	00	51	1/1700
339	3,002.64	0.568	00	04	1/6500

TABLE 65 (*Continued*)

Traverse Number	Length of Traverse Feet	Length of Traverse Miles	Azimuth Closure Error Minutes	Azimuth Closure Error Seconds	Error of Closure
340	5,122.79	0.970	00	36	1/3739
341	4,216.90	0.798	00	03	1/4300
342	5,233.59	0.990	00	16	1/3800
343	1,834.47	0.347	00	05	1/2911
344	3,742.92	0.709	00	40	1/2012
345	987.28	0.187	01	50	1/7594
346	1,718.55	0.325	00	40	1/1273
347	2,563.77	0.485	00	03	1/1473
351	11,931.79	2.260	00	00	1/5077
352, 353	27,985.69	5.300	00	57	1/3124
353L, 353V	1,700.07	0.322	00	20	1/1570
354	5,599.93	1.060	00	50	1/3140
355	5,668.76	1.072	00	00	1/19500
356	9,494.34	1.798	00	10	1/4230
357, 316	4,427.99	0.837	00	20	1/1800
358	9,470.73	1.797	01	37	1/14100
359	4,995.73	0.945	00	30	1/5110
600A to 603R	20,747.78	3.920	00	12.3	1/5700
603T to 605B	12,001.68	2.275	01	07.1	1/3727
604R to 604Y	3,879.95	0.735	00	45	1/2337
604Z to 607E	9,240.22	1.748	00	45	1/4995
608A to 608X	6,988.16	1.322	00	36	1/3119
609A to 610G	11,310.75	2.140	01	47	1/3065
611B to 611P	5,233.19	0.991	01	24.6	1/3584

TABLE 65 (*Concluded*)

Traverse Number	Length of Traverse Feet	Length of Traverse Miles	Azimuth Closure Error: Minutes	Azimuth Closure Error: Seconds	Error of Closure
611P to 611S	3,597.72	0.680	00	15	$\frac{1}{3598}$
612	14,131.33	2.675	01	01.6	$\frac{1}{7807}$
613	11,823.19	2.240	01	40	$\frac{1}{1300}$
614	9,259.13	1.754	01	06	$\frac{1}{5612}$
615	10,854.99	2.054	00	23	$\frac{1}{9900}$
616A to Westhead	16,165.91	3.060	02	00	$\frac{1}{7772}$
616AE to 616M	10,380.83	1.965	00	10	$\frac{1}{4553}$
617A to 617BC	18,082.67	3.420	00	06	$\frac{1}{4000}$
617BD to 617BY	5,139.13	0.972	..	..	....
618	9,770.03	1.850	00	40	$\frac{1}{4500}$
619A to 619AA	13,492.15	2.550	..	..	$\frac{1}{5000}$
619AB to 619AF	3,709.28	0.702	..	..	....
620	8,101.08	1.533	00	02	$\frac{1}{4400}$
621	4,426.28	0.838	00	30	$\frac{1}{6147}$
622	5,998.74	1.136	00	05.5	$\frac{1}{2884}$
623	7,194.31	1.361	00	35	$\frac{1}{1300}$
624	4,548.34	0.860	00	20	$\frac{1}{2485}$
625	18,558.97	3.515	00	50	$\frac{1}{11247}$
632	2,232.57	0.423	00	10	$\frac{1}{1890}$
633	11,956.22	2.260	..	..	$\frac{1}{20375}$
634	17,826.22	3.375	02	40	$\frac{1}{4270}$
635 and 636	Not computed	.....	02 01	00 50	Not computed

Average error of closure $\frac{1}{5900}$

STADIA SURVEYS IN NASSAU COUNTY

In this work only one U. S. Coast Survey station was used as a control. This one being "Episcopal Church spire," South Oyster bay (Massapequa), one continuous traverse being carried from Hospital station in Amityville to "Roeckels" at Rosedale. For this work a party was made up as follows: Assistant engineer in charge, one instrument man (either a topographical draftsman, rodman or axeman), one recorder, and from four to six axemen and laborers to run stadia rods, clear the line and chain the distance between stations.

A party made up in this manner could cover about one mile a week on a strip about 600 to 2000 feet in width. This depended a good deal upon the nature of the country; the rate of progress was very much slower through the villages of Freeport and Lynbrook. The first closure was made at Massapequa on the U. S. Government station and was 1 in about 9000. In closing through from Massapequa to Rosedale, the error in azimuth was about eight minutes and in closure 1 in 5059. This error in azimuth would have been decreased about four minutes if the corrections had been made at Freeport and Lynbrook that were determined by the observation on Polaris. Average closure of all traverses 1/9800.

Length of traverses, miles	33.8	
Number of stations	264	
Approximate number of shots	6,054	
Area		
Square miles	6.3	
Acres	4,032	
Number of topographical sheets	27	
Total cost, including salaries, team hire and traveling expenses (field expenses only)		$3,094.01
Cost		
Mile of traverse		$91.54
Per square mile		491.11
Per acre		0.77

Errors of closure of the traverses in Nassau county are shown in the following table:

Traverse Number	Length of Traverse Feet	Length of Traverse Miles	Azimuth Closure Error Minutes	Seconds	Error of Closure
39	6,280.19	1.189	00	31	$\frac{1}{22302}$
40	10,876.00	2.056	01	41	$\frac{1}{4880}$
105	4,680.5	0.884	00	11	$\frac{1}{6000}$
106	7,319.27	1.386	00	38	$\frac{1}{13140}$
225	84,653.2	16.035	08	51	$\frac{1}{5059}$
229	15,153.05	2.881	00	21	$\frac{1}{7360}$

Average error of closure $\frac{1}{9800}$

STADIA SURVEYS IN THE COUNTY OF QUEENS

With the azimuth stakes already established at Ridgewood reservoir, "Aqueduct," "Metropolitan," and "Roeckels," the stadia surveys were carried east, beginning at Ridgewood reservoir. These closed on the three latter stations very satisfactorily, only a few being below the standard of 1 in 5,000, and one being as high as 1 in 754,000, the average closure being one in 67,300.

For this work a party of nine men were used, made up as follows:

Assistant engineer in charge, instrument man, recorder, and four to six rodmen.

A Buff and Buff 5-inch 20-second transit was used with the ordinary low tripod. On this work the traverse line was run first, measuring the angles and distances; the topography was taken later. The angles were always measured from left to right sighting on the rear station, three to six angles being turned. The magnetic bearing was read on both lines, and as a check on the angle work before taking any topography, the instrument was set on the back station on the back azimuth and turned on the forward station, and the azimuth read. Level readings were taken both ways to determine the eleva-

tion of the hubs. On this work, a strip averaging about 1,500 feet in width was taken.

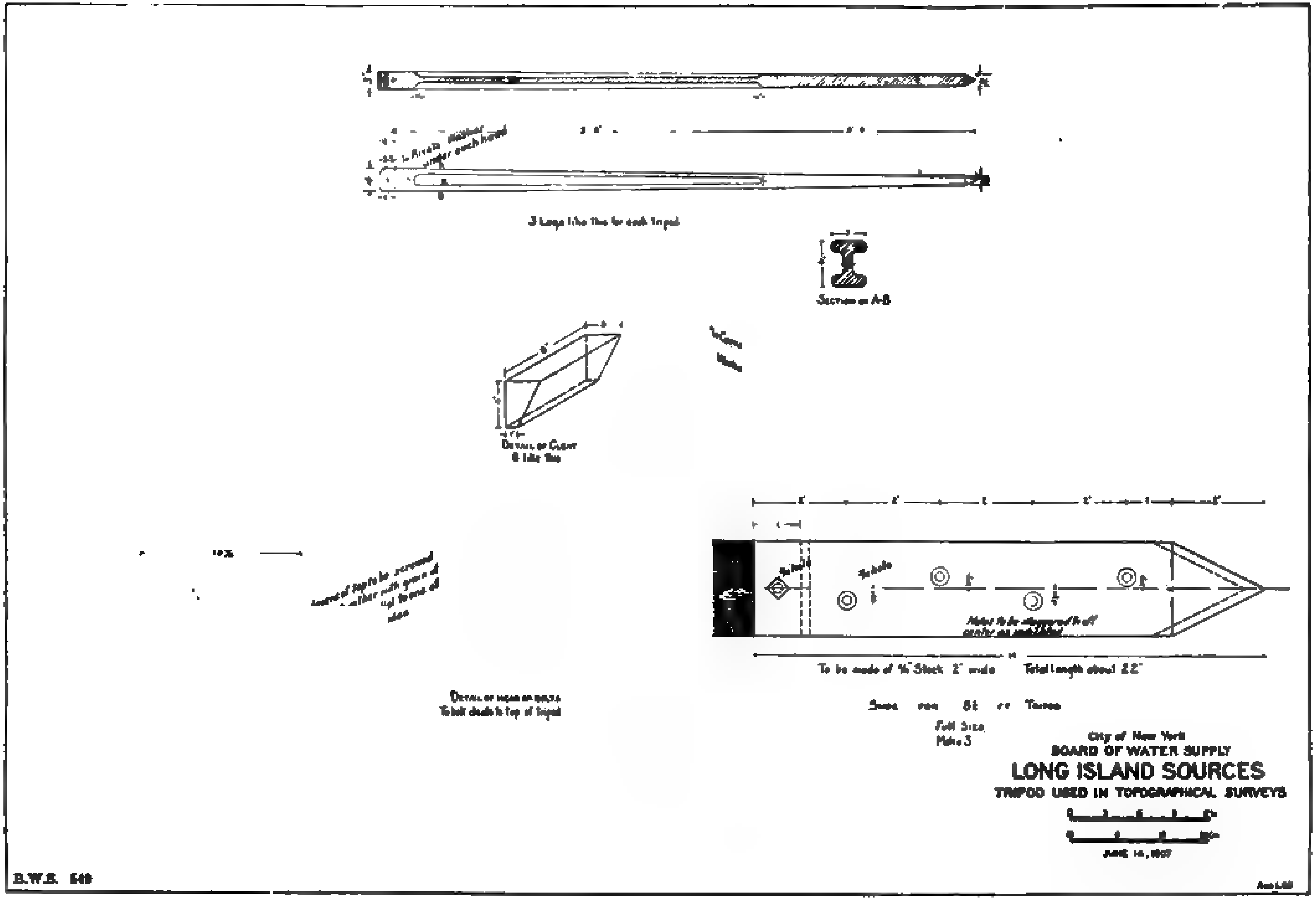
Length of traverse in miles	28½	
Number of stations set	340	
Approximate number of shots	8,200	
Area covered		
Square miles	4.28	
Acres	2,740	
Number of topographical sheets (26 inches by 40 inches)	19	
Salaries and expenses, including supplies, materials, etc. (no executive)		$9,400.00
Cost		
Per mile of traverse		$330.00
Per square mile		22.20
Per acre		3.43

Errors of closure of the traverses in Queens county are shown in the following table:

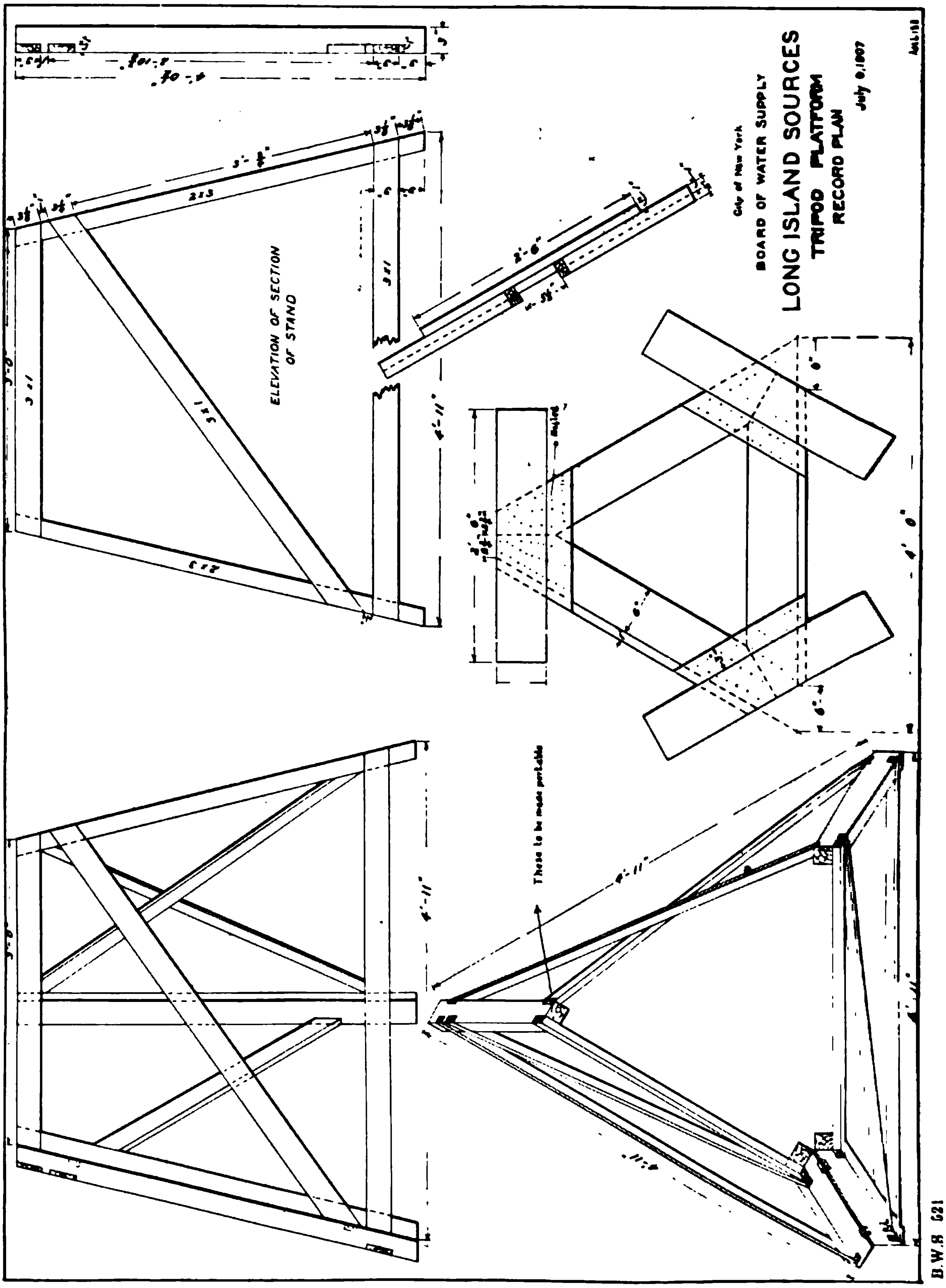
Traverse Number	Length of Traverse Feet	Length of Traverse Miles	Azimuth Closure Error Minutes	Azimuth Closure Error Seconds	Error of Closure
900, 901	20,615.09	3.89	03	38	$\frac{1}{5800}$
902	17,072.03	3.23	01	02	$\frac{1}{3600}$
903	21,427.84	4.05	03	36	$\frac{1}{4550}$
904	13,566.26	2.56	Connected with traverse from Amityville		
906	10,460.22	1.98	00	46	$\frac{1}{19000}$
907	6,516.60	1.23	01	57	$\frac{1}{40400}$
908	7,542.49	1.43	00	12	$\frac{1}{754200}$
909	15,159.66	2.87	01	15	$\frac{1}{3100}$
910	1,942.80	0.37	00	39	none
911	10,654.80	2.02	01	22	$\frac{1}{10500}$
912	2,163.55	0.41	02	40	.....
914	3,321.29	0.63	00	26	$\frac{1}{5600}$

Traverse Number	Length of Traverse Feet	Length of Traverse Miles	Azimuth Closure Error		Error of Closure
			Minutes	Seconds	
950	7,239.06	1.37	00	07	$\frac{1}{14300}$
951	3,375.95	0.64	00	46	$\frac{1}{2100}$
1001	25,203.83	4.77	01	05	$\frac{1}{4200}$
1002	18,612.89	3.52	02	33	$\frac{1}{7000}$

Average error of closure $\frac{1}{67300}$


3 Legs like this for each tripod
Section on A-B
Detail of Cleat
6 like this
Holes to be staggered ¼" off center as indicated
To be made of ⅛" Stock 2" wide
Total length about 22"
Full Size
Make 3
Detail of head of brass
To bolt clock to top of tripod
City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
TRIPOD USED IN TOPOGRAPHICAL SURVEYS
B.W.S. 549

SHEET 176


City of New York
BOARD OF WATER SUPPLY
LONG ISLAND SOURCES
TRIPOD PLATFORM
RECORD PLAN
July 9, 1907
ELEVATION OF SECTION OF STAND
These to be made portable
B.W.S. 621

Stadia party using 8½-foot tripod.

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